Dissertation on

A STUDY OF POPLITEAL ARTERY AND ITS VARIATIONS WITH CLINICAL APPLICATIONS.

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Madras Medical College and Rajiv Gandhi Government General Hospital,

Chennai - 600 003

THE TAMILNADU Dr.M.G.R. MEDICAL UNIVERSITY

CHENNAI – 600 032

TAMILNADU

MAY-2018

CERTIFICATE

This is to certify that this dissertation entitled **"A STUDY OF POPLITEAL ARTERY AND ITS VARIATIONS WITH CLINICAL APPLICATIONS"** is a bonafide record of the research work done by **Dr.N.BAMA**, Post graduate student in the Institute of Anatomy, Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai-03, in partial fulfillment of the regulations laid down by The Tamil Nadu Dr.M.G.R. Medical University for the award of M.D. Degree Branch XXIII-Anatomy, under my guidance and supervision during the academic year from 2015-2018.

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CERTIFICATE OF APPROVAL

To
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Dear Dr.N.Bama,

The Institutional Ethics Committee has considered your request and approved your study titled **"A STUDY OF POPLITEAL ARTERY AND ITS VARIATIONS WITH CLINICAL APPLICATIONS " NO. 25072016.**

The following members of Ethics Committee were present in the meeting hold on **05.07.2016** conducted at Madras Medical College, Chennai 3

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2.Prof. Isaac Christian Moses,MD.,Dean(FAC)MMC ,Ch-3	Deputy Chairperson
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13.Tmt.ArnoldSaulina, MA., MSW.,	Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary – Ethics Committee

MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
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This is to certify that this dissertation work titled **"A STUDY OF POPLITEAL ARTERY AND ITS VARIATIONS WITH CLINICAL APPLICATIONS"** of the candidate **DR.N.BAMA** with registration Number **201533001** for the award of **M.D** in the branch of **ANATOMY**. I personally verified the urkund.com website for the purpose of plagiarism Check. I found that the uploaded thesis file contains from introduction to conclusion pages and result shows **7 percentage** of plagiarism in the dissertation.

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LEGEND

PA	-	Popliteal artery
BSA	-	Body surface area
SMGA	-	Superomedial genicular artery
SLGA	-	Superolateral genicular artery
IMGA	-	Inferomedial genicular artery
ILGA	-	Inferolateral genicular artery
MGA	-	Middle genicular artery
ATA	-	Anterior tibial artery
PTA	-	Posterior tibial artery
PRA	-	Peroneal artery
POP	-	Popliteus muscle
TN	-	Tibial nerve
PV	-	Popliteal vein
FC	-	Femoral condyle
FA	-	Femoral Artery
AH	-	Adductor hiatus
HDPA	-	High division of popliteal artery
et al	-	and others

CONTENTS

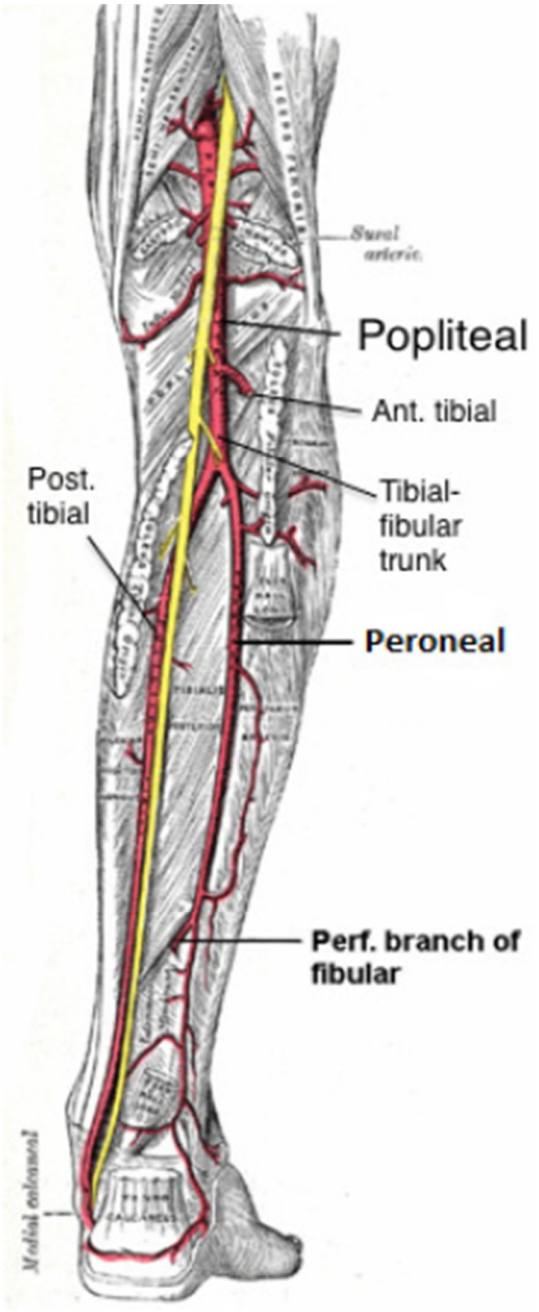
Introduction

INTRODUCTION

The Popliteal artery is the continuation of the femoral artery**(FA)** from the fifth osseo aponeurotic opening in adductor magnus to the femoral intercondylar fossa. It runs obliquely to the distal border of popliteus, where it divides into anterior and posterior tibial arteries. Thus the popliteal artery extends from the medial border of the femur to the laterally placed interosseous space, accounting for its oblique descent. The artery is relatively tethered at the hiatus of adductor magnus**(AH)** and distally by the fascia related to the soleus. It is therefore prone to traction damage in knee injuries.

RELATIONS

Anterior - From proximal to distal, are fat covering the femoral popliteal surface, the capsule of the knee joint and the fascia of popliteus. **Posterior -** From proximal to distal, are the semimembranosus, gastrocnemius and plantaris muscles. At the intermediate level the artery is separated from the skin and fascia by fat. It is crossed posteriorly(from lateral to medial) by the tibial nerve and popliteal vein, the vein being between the nerve and artery, adherent to the latter. **Lateral –**From proximal to distal are the biceps femoris muscle, tibial nerve, popliteal vein, lateral Femoral condyle**(FC)**, the plantaris and lateral head of gastrocnemius. **Medial –** Proximal to distal are the semimembranosus, medial FC, tibial nerve**(TN)**, popliteal vein**(PV)** and medial head of gastrocnemius.



Course of Popliteal Artery

BRANCHES

- Cutaneous branches
- Muscular branches
- Genicular branches
- Terminal branches

CUTANEOUS BRANCHES

It supplies the skin on the flexor aspect of the leg; one usually that accompanies the small saphenous vein.

MUSCULAR BRANCHES

Two or three branches arise proximally and pass to the adductor magnus and femoral flexors. Sural arteries two in number arise behind the knee joint to supply the gastrocnemius, soleus and plantaris muscles.

GENICULAR BRANCHES

Superior medial genicular artery (SMGA) lies under semimembranosus and semitendinosus, proximal to the medial head of the gastrocnemius and deep to the adductor magnus tendon. It gives off a branch to the vastus medialis, which anastomoses with descending genicular and inferior genicular artery. The **Superior lateral genicular artery(SLGA)** divides into superficial and deep branches. The superficial branch supplies the vastus lateralis, anastomosing with the lateral inferior genicular branch, descending branch of the lateral circumflex femoral artery, while the deep branch anastomoses with medial superior genicular artery.

The **middle genicular artery(MGA)** is small branch, which arises from the popliteal artery near the posterior centre of the knee joint. It pierces the oblique popliteal ligament to supply the cruciate ligament and synovial membrane.

The **inferior genicular arteries** arise from the popliteal artery deep to the gastrocnemius. It gives off the medial and lateral branch. The medial branch anastomoses with the lateral inferior, medial superior genicular arteries, anterior tibial recurrent artery and saphenous branch of the descending genicular artery. The lateral branch runs laterally across the knee joint, passing under the lateral head of gastrocnemius and tendon of biceps femoris. Its branches anastomose with medial inferior and lateral superior genicular arteries, circumflex fibular artery, anterior and posterior tibial recurrent arteries.

The genicular anastomoses exists around the patella, femoral and tibial condyles. A superficial network spreads between the fascia and skin around the patella. A deep network lies on the femur and tibia near the adjoining articular surfaces, supplying the bone, the articular capsule and synovial membrane.

TERMINAL BRANCHES

The terminal branches of the popliteal artery arise at the distal border of popliteus muscle**(POP)**, which divides in to anterior tibial and posterior tibial arteries.

THE ANTERIOR TIBIAL ARTERY(ATA)

After the origin, the anterior tibial artery lies in the flexor compartment, which passes between the heads of tibialis posterior and through the oval aperture in the proximal part of the interosseous membrane. It then enters the extensor region passing medial to the fibular neck. It descends anteriorly on the membrane and approaches the tibia that lies anterior to it. At the ankle it is midway between the malleoli, continuing on the dorsum as the dorsalis pedis artery. The branches of anterior tibial artery are anterior and posterior tibial recurrent, anterior medial and lateral malleolar and muscular.

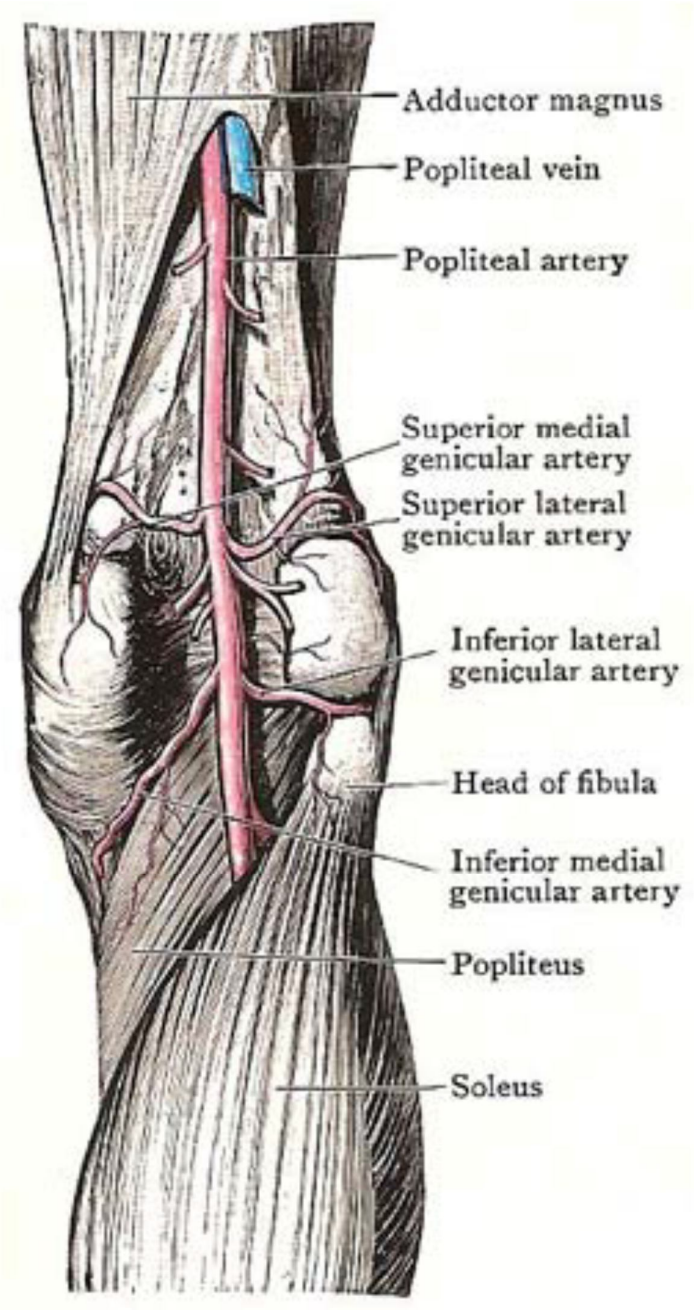
The **dorsalis pedis** artery is the continuation of anterior tibial artery distal to ankle. It passes medially along the dorsum to the proximal end of first intermetatarsal space, where it turns into the sole to complete the plantar arch and gives off the first plantar metatarsal artery. The branches are tarsal, arcuate and first dorsal metatarsal arteries.

POSTERIOR TIBIAL ARTERY (PTA)

The PTA begins in the distal border of popliteus muscle ,and descends medially in the flexor compartment and divides under abductor hallucis,midway between medial malleolus and medial tubercle of the calcaneum ,into the medial and lateral plantar arteries. The artery may be hypolastic or absent ,peroneal artery takes over its distal supply to foot and also increase in size.

PERONEAL ARTERY (PRA)

The peroneal artery is deeply seated on the back of fibula It usually arises from PTA ,about 2.5 cm below the lower border of popliteus muscle,passes obliquely towards the fibula.It descend in a fibrous canal between tibialis posterior and the flexor hallucis longus muscle, runs behind the tibiofibular syndesmosis and divides into lateral calcaneal branches which supply the lateral and posterior surface of the calcaneum.



Branches of Popliteal Artery

RELATIONS IN POPLITEAL FOSSA

The popliteal artery is crossed superficially by popliteal vein from the lateral to medial side. The relative relationship of these structures differs in the upper, middle and lower parts of the popliteal fossa.

Upper part

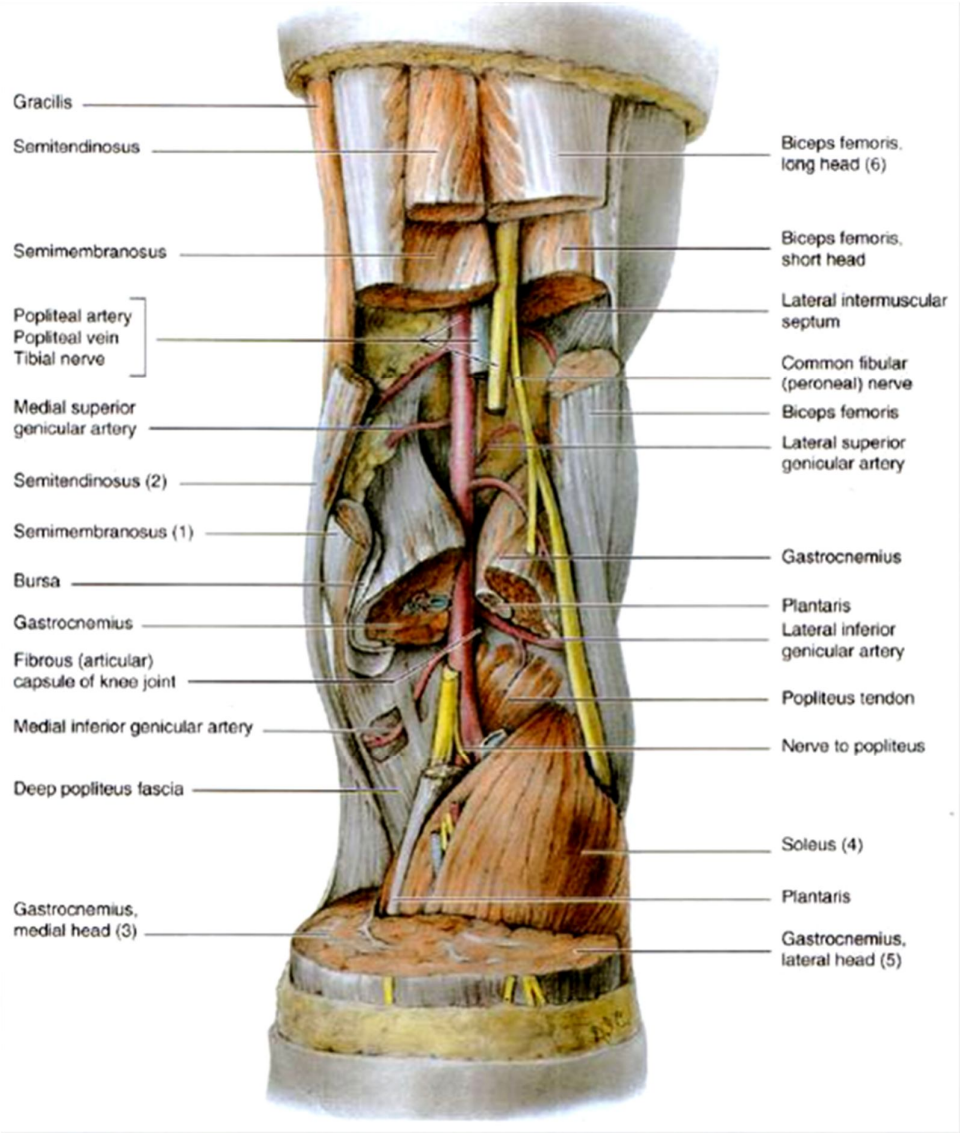
From lateral to medial side, the order is Nerve, Vein, Artery (NVA).

Middle part

From superficial to deep, the order is Nerve, Vein, Artery (NVA).

Lower part

From lateral to medial side, the order is Artery, Vein and Nerve (AVN).



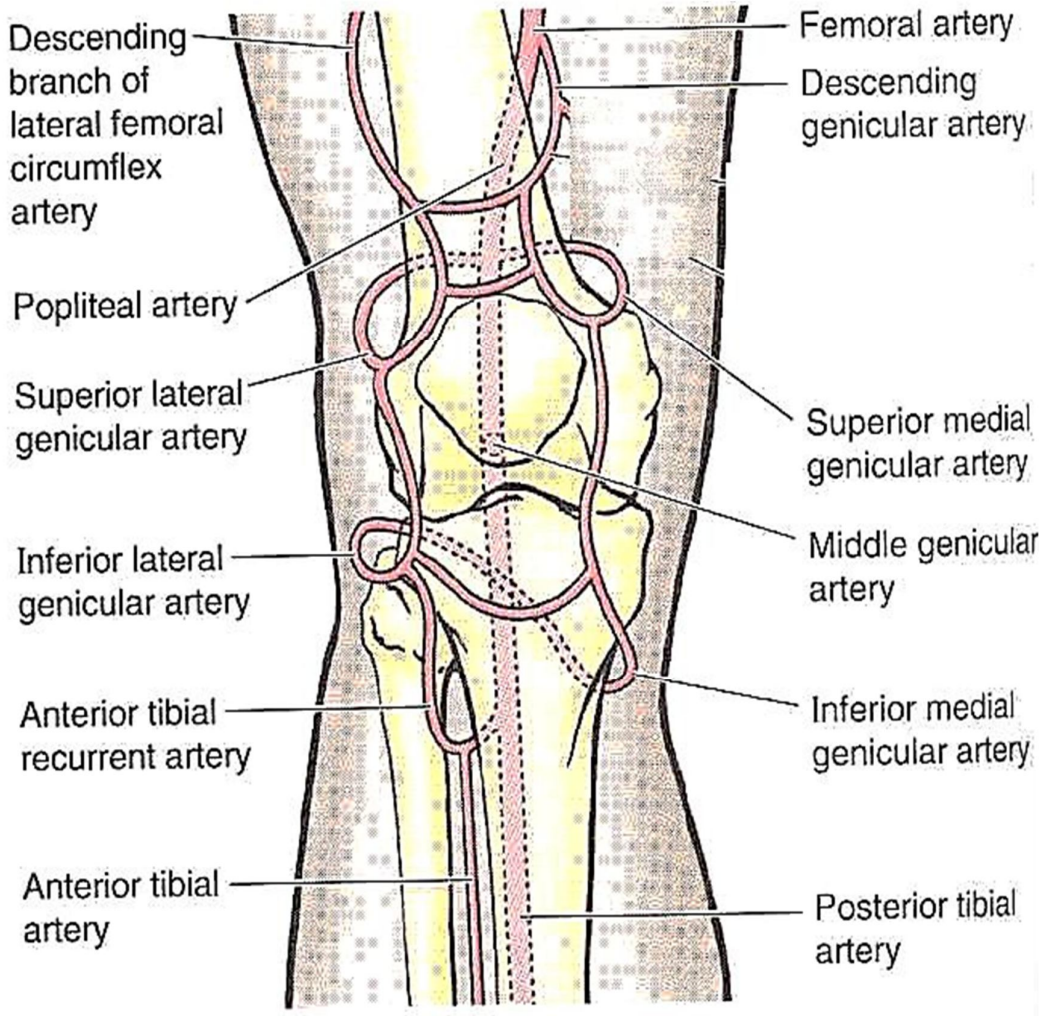
RELATIONS IN POPLITEAL FOSSA

GENICULAR ANASTOMOSIS

It is an arterial anastomosis around the knee joint formed by the branches of popliteal, anterior tibial and posterior tibial, femoral and profunda femoris arteries.

This anastomosis maintains adequate blood supply to the knee joint and leg during flexion of the knee joint, when the popliteal artery is compressed and blood flow in it becomes sluggish. The anastomosis takes place as follows

1. Superior medial genicular artery(SMGA) anastomosis with the descending genicular branch of femoral artery and inferior medial genicular artery(IMGA).
2. Inferior medial genicular artery(IMGA) anastomosis with superior medial genicular artery(SMGA) and saphenous artery.
3. Superior lateral genicular artery(SLGA) anastomosis with the descending branch of lateral circumflex femoral artery and inferior lateral genicular artery(ILGA).
4. Inferior lateral genicualr artery(ILGA) anastomosis with the superior lateral genicular artery(SLGA), anterior and posterior recurrent branches of the anterior tibial artery and circumflex fibular branch of PTA**. (Susan standring[69],GRAYS ANATOMY)**



Genicular Anastomosis

Aim of the study

AIM OF THE STUDY

The popliteal artery is the continuation of FA beyond the fifth osseo aponeurotic opening in the adductor magnus muscle. It is deeply seated in the popliteal fossa and an important landmark in surgical procedures around knee joint.

Anatomical variations in the popliteal artery influence the prognosis of most of the surgical procedures in the knee joint. The two most common variations are high division and trifurcation.

The popliteal artery is relatively tethered to the adductor magnus hiatus and distally by the fascia related to soleus. The close relationship of this artery with femur and tibia in the knee region explains the frequent association of vascular injuries with fractures and dislocations of this joint.. It also increases the risk of unnecessary haemorrhage during arthroscopic procedures of knee joint.

An anomalous relationship between the popliteal artery and the adjacent musculotendinous structure can lead to entrapment syndrome(CLASSICAL FORM). Knowledge of the popliteal artery development provides better understanding of the pathogenesis of aneurysm and entrapment syndrome. In the functional form of Popliteal artery entrapment syndrome(PAES),hypertrophy of gastrocnemius muscle secondary to exercise has been postulated as a cause. It is also important to anticipate the complications due to PAES.

The popliteal artery acts as a common site for above and below knee bypass grafts.

The knowledge of variations in the branching pattern of the popliteal artery is important for a successful arthroscopic surgery, vascular grafting, direct surgical repair, transluminal angioplasty, embolectomy and for the diagnosis of arterial injury. Hence the study of Popliteal artery and its variations will be helpful, before proceeding any diagnostic, interventional and surgical procedures in knee joint.

Despite improvement in vascular surgical techniques, patient with high origin of ATA lying posterior to popliteus are vulnerable to arterial complications like fistula, transection , pseudo-aneurysm, thrombosis..

In case of Trifurcation of popliteal artery, angioplasty or embolectomy will be technically difficult.

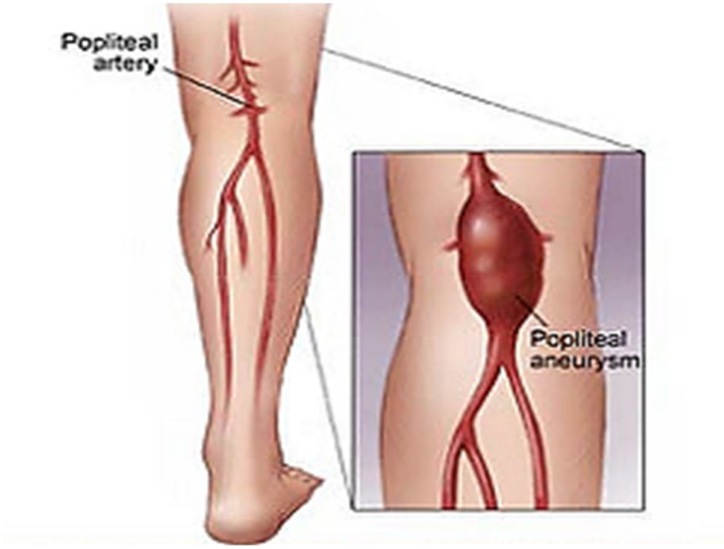
Peroneal artery perforator flap is used in reconstruction of defects at the lateral aspect of the middle and distal third of leg ,ankle and Achilles tendon region. If there is a hypoplasia of both ATA and PTA, harvesting of PRA is contraindicated. since PRA is only artery that feeds the distal parts of the lower limb.

Lateral flap of the thigh is based upon the superior lateral genicular artery .It also used in lateral and superior defects of the knee.

Cystic adventitial disease is one of the rare non- artherosclerotic causes of isolated occlusive peripheral arterial disease. It most commonly affects PA and is characterized by a cyst in adventitial layer of blood vessel wall .It causes a local narrowing in the arterial lumen and may lead to intermittent claudication.

POPLITEAL ARTERY ANEURYSM

Popliteal artery aneurysm is the most common peripheral aneurysm accounting for 70-80%. Atherosclerosis, hypertension and the fixation of the vessel to AH are usual causes of this condition. The non-atherosclerotic process is very rare and may occur as a complication of inflammatory diseases or trauma. The major complications of aneurysm are chronic embolization, thrombosis and acute ischemic complications. The standard surgical treatment is vein interposition, but now due to high morbidity of standard procedures trans femoral endoluminal graft stenting is an alternative approach to conventional procedures.



Popliteal Artery Anerysum

PARAMETERS

1. Origin of Popliteal artery
2. Course of Popliteal artery
3. Length of Popliteal artery
4. Diameter of Popliteal artery
5. Genicular branches of Popliteal artery
6. Level of terminal division of Popliteal artery
7. Branching pattern of the terminal division of the popliteal artery.

Review of literature

REVIEW OF LITERATURE

1. ORIGIN OF POPLITEAL ARTERY

George A. Piersol[46] (1930) stated that PA is the continuation of the FA and extends from the point where the latter pierces the adductor magnus to the lower border of popliteus.

G.J.Romanes [55](1964) in Cunninghams text book of anatomy mentioned that PA is the direct continuation of the FA, which begins at the medial end of the upper part of the popliteal fossa to the distal border of POP, at the level of the tuberosity of the tibia.

W. Henry Hollinshead[21] (1969) stated that FA passes through the AH and reaches the posterior aspect of the lower part of the thigh where it is known as PA**.**

J.C.B. Grant [18](1989) described that the FA becomes the PA by passing through a gap or hiatus in the insertion of adductor magnus, 10 cm superior to adductor tubercle.

R. F. Neville et al [41](1990) in their study reported a congenital absence of PA, during operative exploration of injured lower limb.

R. J. Last[31] (1999) stated that the PA is the deepest of the neurovascular structures in the popliteal fossa. It extends from the hiatus in the adductor magnus to the fibrous arch in the soleus muscle.

D. K. Kadasne[24] (2009) stated that the PA runs as a continuation of FA beyond the opening in adductor magnus.

Richard S. Snell[66] (2010) quoted that the PA enters popliteal fossa through the opening in the adductor magnus, as a continuation of FA. It ends at the level of lower border of popliteus into ATA and PTA.

In **Gray's Anatomy[69] (2012),** Susan Standring stated that PA is the continuation of FA. Sometimes it may arise as a continuation of the sciatic artery which is a branch of inferior gluteal artery.

Keith L. Moore et al[37] (2013) illustrated that PA is the continuation of the FA begins when the latter passes through the AH.

Mustafi [40]described that PA is the continuation of the FA. It begins at the aperture in the adductor magnus and ends below at the lower border of the popliteus.

2. LENGTH OF POPLITEAL ARTERY

H.Gaylis [17](1974) in his arteriographic study noted that the average length of the PA was 17.5 mm.

Ozgur et al[42] (2009) in his study on 40 lower limb specimens obtained from 19 male cadavers and 21 female cadavers had measured the length of PA from various anatomical landmarks. They found that the length of PA from the AH to the origin of ATA was 191.1 ± 34.7 mm, from AH to FCs was 138.1 ± 23.8 mm. The length of tibio-peroneal trunk was 30.3 ± 16.2 mm.

Cagatay Barut et al[4] (2009) dissected popliteal fossa in 28 lower limbs specimens for his study. The mean length of the PA from the AH to the FCs was measured as 92.6 ± 16.3 mm on the right side and 100.8 ±21.2 mm on the left side. The mean distance from the FCs to its termination was observed to be 72 ± 19.8 mm on the right side and 66.9 ± 11.5 mm on the left side. Average arterial length from the level of FCs to the site of origin of PRA was 100.1±17.8mm on right side and 91.8±10.7mm on the left side.

Selda et al[60] (2010) observed that the length of the PA from AH to the bifurcation point was 126.82mm.The bifurcation level of PA into a ATA and PTA was 16.07mm distal to the upper border of popliteus muscle. The length of PTA till the branching point of PRA was 77.4 mm and the distance between the lower border of the POP and branching point of PTA was10.02mm.

Ankit khandelwal [26](2014) in his study on 40 lower limb specimens reported that the average length of PA was observed to be 11.2 cm in contrast to normal length ranging from 18-20 cm.

Telang et al[71] (2016) dissected 50 human cadavers and reported that the mean length of PA from apex of AH to the distal edge of FCs was 149.7 mm on the right side and 149.2 mm on the left side. The mean length of the PA from the distal edge of FCs to its termination was 59.2 mm on the right side and 60.6 mm on the left side. The mean length of PA from AH to its termination on the right side and left side was 208.7 mm and 208.8 mm respectively.

3. DIAMETER OF THE POPLITEAL ARTERY

Johnston et al[23] (1991) reported that the mean diameter of PA was 9.1± 2.1mm.

Zierler et al[75] (1983) stated that the mean diameter of PA was 5.2 ± 1.1 mm.

Sidaway AN et al[62] (1986) observed that the luminal diameter of ATA is most important determinant of patency rate in anterior femoro-tibial graft. The 3 yr patency rate of graft is 63%. A hypoplastic ATA was observed in 1.98% of cases, where the dorsalis pedis artery was replaced by the perforating branch of the PRA.

Macchi et al[34] (1994) examined 50 healthy men and women with duplex ultrasound scanning and the mean PA diameter was found to be 5.1 ± 0.4 mm in men, 5.0 ± 0.4 mm in women.

Sandgren et al[59] (1998) screened 121 healthy volunteers and reported the range of PA diameter as 6.9 to 8.4 mm in men and 5.7 to 7.2 mm in women depending on the BSA and age.

Crawford et al[11] (1998), in a sonographic study found that the mean PA diameter was 7.2mm and 6.1mm in male and female respectively.

Debasso et al [15](2004) In their study on 52 healthy men and 56 healthy women, observed the mean PA diameter as 7.4 mm and 6.3 mm in male and female respectively.

Morris-stiff et al [39](2005) screened 449 patients for the presence of PA aneurysm and reported that the mean diameter of PA as 7.4 ± 1.3 mm.

Wolf et al [74](2006) reported the mean PA diameter as 6.8 ± 0.8 mm in men and 6.0±0.7 mm in women.

Ozgur et al[42] (2009) dissected 40 lower limb specimens and noted the diameter of PA at a level 5 cm distal to the AH as 8.2 ± 1.6 mm. The diameter at the level of distal edge of FCs was 7.5 ± 1.3 mm.

Bergmann R A et al[52] (2010) reported that PTA may be hypoplastic and its diameter reduced to 1-2 mm in lower third of the leg

Selda Yildiz et al [60](2010) in their study said that the mean diameter of PA was 8.3mm.The diameter of high origin ATA, PTA were 3.15mm and 4.83mm respectively. PTA diameter after it gives off PRA was 3.44mm and PRA diameter was 4.44mm.The diameter of PTA was observed to be smaller than PRA.

Krzysztof et al[30] (2016) in his study reported the mean diameter of PA as 8±1.2mm

4. BRANCHES OF POPLITEAL ARTERY

G.J.Romanes[55] (1964) in Cunninghams text book of anatomy quoted that the branches of PA are muscular and genicular branches. Muscular branches gives twig to hamstring and muscles of the calf. Five genicular branches are SMGA, SLGA, MGA, IMGA, ILGA.

Henry Hollinshead[21] (1997) stated that the PA gives rise to five genicular branches and muscular branches. Muscular branches supplies the muscles of popliteal fossa.

Keith (L) Moore[37] (2006) quoted that the PA has genicular and muscular branches.

D. K. Kadasne [24] (2009) mentioned that the PA gives rise to cutaneous, genicular and muscular branches.

Susan Standring[69] (2012) mentioned that PA has

- Five genicular branches
- Superior muscular branches: to adductor magnus and hamstrings muscles.
- Inferior muscular branches: Supplies Gastrocnemius, soleus and plantaris muscles. The largest branch is sural artery.
- Cutaneous branches.

Ozgur et al[42](2009) in his cadaveric study, observed that the ILGA arises from ATA and the IMGA arises from common tibio -peroneal trunk

Salaria and Atkinson et al[57] **(2008)** dissected eighteen lower limb specimens and reported that the MGA and SLGA arise from a common trunk in 12.5% .

Singla et al[63] **(2012)** dissected 60 lower limb specimens and observed that there was a common trunk for MGA, SLGA in 1.6 % of the specimens.

Billakanti et al[7] **(2014)** in his cadaveric study noted that IMGA which is usually a branch of PA was found to be arising from ATA.

Bettaiah et al[5] **(2016)** dissected 40 lower limb specimens. in 5% of the specimens, a common trunk giving rise to MGA, SLGA and SMGA was found.

LSB Franci et al[32]**(2016)**observed a unique case of bilateral aberrant medial plantar arteries arise from PA.

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5. TERMINAL DIVISION OF POPLITEAL ARTERY

Pearson F.G et al[44] (1898) reported that the terminal division of PA occurs at the lower border of popliteus muscle in 90% of the specimens.

R.D.Lockhart et al[54] (1959) observed that the PTA is the largest and direct terminal branch of PA .PTA gives origin to PRA, an inch below the POP.

Morris et al [38](1961) They did angiographic studies on 246 lower limb extremities and reported the following pattern of termination.

- Normal pattern -88.6%
- Trifurcation pattern - 2.9%
- Anterior tibio-peroneal trunk - 1.2%

W.Henry Hollinshead[21](1969) He has mentioned that the PRA may arise from ATA rather than PTA . Sometimes PTA may be small in caliber after giving off the PRA but attains its usual caliber after joining with the communicating branch of the PRA at the ankle.

Keith L. Moore[37] (1980) in clinically oriented anatomy book mentioned that PTA begins at the lower border of the POP between the tibia and fibula, and it is the largest terminal branch of PA. PRA is the most important branch of PTA, which is given off 2-3cm inferior to the distal border of popliteus.

Sanders RJ, Alston G[58] (1986) in their angiographic study in 147 patients (294 limbs), reported the following pattern of terminal division:

- Normal pattern- 97%
- High origin of PTA-3% .

Zwass et al[76]**(1986)**: reported a case of Hypoplastic ATA and it was associated with hypertrophic PRA .

In **Ducksoo Kim et al**[28] **(1989)** described the surgical importance of PA variations. He classified the branching pattern of terminal division of PA into **3** types :

1. Normal level of popliteal artery termination:

- **Type 1 A**: Normal pattern; ATA arises first, common tibio peroneal trunk branches into peroneal and posterior tibial arteries.
- **Type 1 B**: Trifurcation pattern- The PA branches into anterior tibial, posterior tibial and Peroneal arteries within 0.5 cm. The tibioperoneal trunk is absent.
- **Type 1 C**: PTA is the first branch – common tibioperoneal trunk divides into anterior tibial and peroneal arteries.

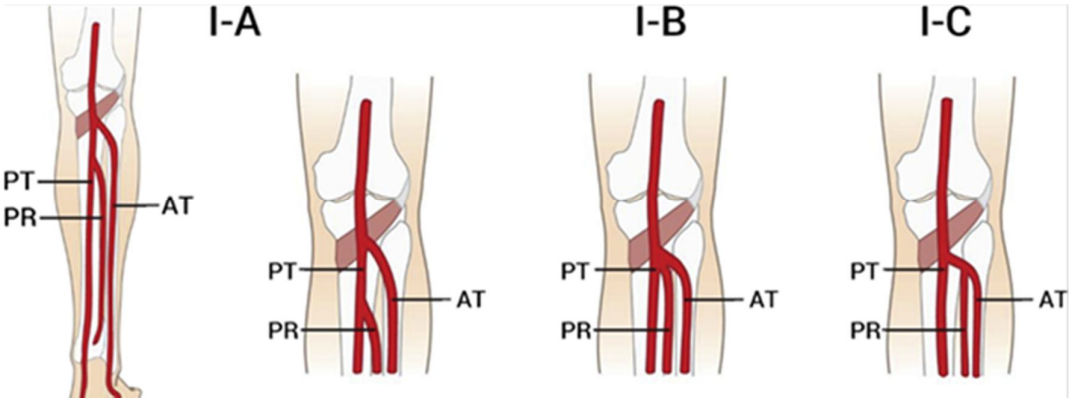


Figure : Type IA: the usual pattern of popliteal artery branching and arterial supply to the foot. **Type IB:** trifurcation: the anterior tibial, peroneal , and posterior tibial arteries arise at the same point without an intervening tibioperoneal trunk. **Type IC:** the posterior tibial artery is the first branch. The anterior tibial and peroneal arteries arise from a common trunk.

2. High level of termination of PA

- **Type II A**1**:** The ATA arises above the knee joint and has a straight course in its proximal segment.
- **Type IIA-2:**The ATA arises above the knee joint but takes a medial swing, presumably resulting from its passage anterior to the POP.
- **Type II B**: PTA arises at or proximal to the knee joint. PRA and ATA arises from common trunk.
- **Type II C:** PRA arises at or proximal to the knee joint. Anterior and posterior tibial arteries arise from a common trunk.

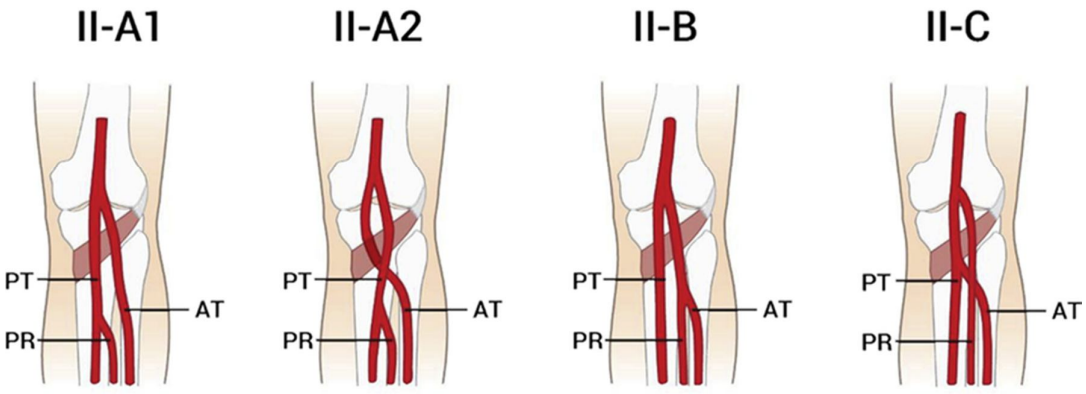


Figure : Type IIA- 1: the anterior tibial artery arises above the knee joint and has a straight course in its proximal segment. **Type IIA-2:** the anterior tibial artery arises above the knee joint but takes a medial swing, presumably resulting from its passage anterior to the popliteus muscle. **Type IIB:** the posterior tibial artery arises at the level of the knee joint. Type IIC: the peroneal artery arises above the knee joint.

3. Hypoplastic or aplastic branching with Altered Distal Supply:

- **Type III A**: Hypoplastic or aplastic PTA. Distal PTA is replaced by PRA.
- **Type III B**: Hypoplastic or aplastic ATA. Dorsalis pedis artery is replaced by PRA.
- **Type III C**: Hypoplastic or aplastic posterior and anterior tibial arteries. Dorsalis pedis artery is replaced by PRA.

Figure : Type IIIA: the posterior tibial artery is hypoplastic and the peroneal artery is large. At the ankle, the distal posterior tibial artery is replaced by the peroneal artery. **Type IIIB:** the anterior tibial artery is hypoplastic and the peroneal artery is large. At the ankle, the dorsalis pedis artery is replaced by the peroneal artery. **Type IIIC:** both the anterior tibial artery and the posterior tibial artery are hypoplastic. At the ankle the dorsalis pedis and posterior tibial arteries are replaced by the peroneal artery.

Kim D et al (1989): in his angiographic study of 605 extremities, reported

- Type I A- Normal pattern- 2.2%
- Type II A-High level origin of ATA- 5.6%
- Type I B-Trifurcation pattern-2.2%

David Harvey[13] (1990) has mentioned that the PA bifurcates into tibioperoneal trunk and the ATA. The Tibioperoneal trunk in turn divides into PRA and PTA.

G.J.Romanes[55] (1996) stated that the PA ends at the inferior border of the popliteus and there it divides into anterior tibial and posterior tibial arteries.

Cornelius Rosse, et al[10](1997) stated that the PA ends by dividing into anterior tibial and posterior tibial arteries at the inferior border of popliteus.

Keith L. Moore[37] (2006) described that the PA ends at the lower border of popliteus by terminating into anterior and posterior tibial arteries.

Piral T et al[47](1996) dissected 40 cadavers and reported that the PTA is absent in 5% of cases.

Tindall AJ[72] (2006) in his angiographic study of 100 lower limbs, observed the following patterns.

- Type I A-Normal pattern -94%
- Type IIA.- High origin of ATA-6%

Szpinda M[56] (2006) in his angiographic study of 152 lower limbs

- Type I A- Normal branching -87.5%.
- Type I B -Trifurcation - 2.63%
- PTA is the first branch of common tibioperoneal trunk -1.97% .
- Type IIA- High level of origin of ATA-1.98%
- Type II B-High level of origin of PTA -5.92%

Day CP et al[12](2006) in his study on 1037 limbs (angiographic study) reported the following Pattern:-

- Type I A - Normal pattern-90.7%
- Type II A- High origin of ATA -4.5%
- Type I B- Trifurcation pattern -3.2%
- Type II B- High origin of PTA-1.1%
- Type II C - High origin of PRA-0.2%
- Type IIIC - Both anterior tibial and posterior tibial arteries are rudiment -0.3%.

Slaba S et al [65](2007) observed an unusual variation of PA, where the PA divides into 4 branches due to early bifurcation of PRA in his cadaveric study.

Ozgur Z et al[42] (2009) in his cadaveric study of 40 lower limbs described the following

- Type I A - Normal pattern -90%
- Type II A- High origin of ATA-5%
- Type I B- Trifurcation pattern - 2.5%
- Type II B- High origin of PTA-2.5%

Arthur F Dallay et al [2](2009) mentioned that in 5% of specimens there was absence of PTA which was compensated by large PRA..

Kil SW et al[27](2009) in angiographic study on 1242 limbs, observed the following:

- Type I A - Normal pattern -89.2%
- Type IIIA- Hypoplastic PTA and large PRA- 5.1%
- Type III B- Hypoplastic ATA and large PRA-1.7%
- Type I B - Trifurcation pattern -1.5%
- Type II A - High origin of ATA-1.2%
- Type III C- Both anterior tibial and posterior tibial arteries are rudimentery . 0.8%.
- Type II B - High origin of PTA- 0.4%
- Type IC - PTA is the first branch; common tibioperoneal trunk- 0.1%

Mavili E et al [36](2011) in angiographic study of 535 lowerlimbs observed the following:

- Type I A- Normal pattern -88.1%
- Type II A - High origin of ATA-5.6%
- Type III C- Both anterior tibial and posterior tibial arteries are rudimentary-6.1%

Kropman et al[29] (2011) in their cadaveric study of 7671 limbs reported

- Type I A - Normal pattern-90%
- Type I B - Trifurcation -7%
- Type III A- Hypoplastic PTA and large PRA-1%
- Type II A - High origin of ATA- 2%

Susan Standring[69] (2012) stated that PA divides at distal border of popliteus

- Normal pattern-90%
- High division -5%
- Trifurcation-5%

Oztekin et al[43](2015) in his angiographic study of 495 extremities reported variation in terminal division in 7.4% to 17.6% .

- Type IA -92.7%.
- TypeIB - 3.8%
- TypeI C-1.6%
- TypeIIA-1.8%
- TypeIIB-1%
- TypeIIIA-3.9%
- TypeIIIB-1 %
- TypeIIIC-0.6%

Krysztof et al[30] (2016) in his study on 12,757 lower limbs

- Normal pattern-97.6%
- Trifurcation-2.4%

Hema et al [22](2016) dissected 40 lower limbs and reported following patterns.

- Normal pattern-95%
- Trifurcation-5%

6. HIGH DIVISION OF POPLITEAL ARTERY(HDPA)

Quain[50](1844) reported 3% of HDPA in his study .

Parson F.G et al[44](1898) reported 8.2% of HDPA among 106 specimens.

Adachi[1] (1928) defined HDPA as any terminal division of PA at a level above the middle of the posterior surface of POP. he observed HDPA in 2.8% out of 770 specimens.

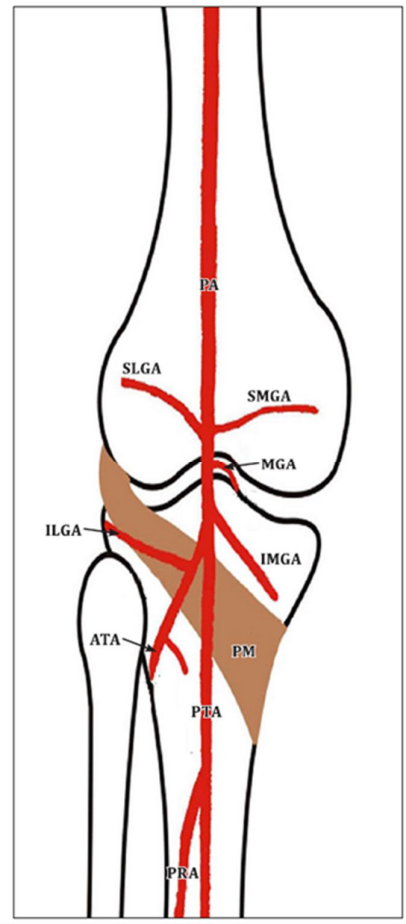


Figure : High Division of Popliteal Artery

According to **Adachi [1](1928**) the HDPA in relation to upper border of POP were grouped in to three types.

Type I

- The PA descends on the posterior surface of the POP.
- The PA divides into ATA and posterior tibioperoneal trunk at the lower border of the POP. The posterior tibioperoneal trunk divides into PRA and PTA.
- The diameter of the ATA was smaller than the posterior tibioperoneal trunk.

Type II

- The PA descends on the posterior surface of the POP.
- It divides into PTA and anterior tibioperoneal trunk. The anterior tibioperoneal trunk divides into the PRA and ATA at the lower border of POP.
- The diameter of the anterior tibioperoneal trunk was observed to be larger.

Type III

- The PA divides into ATA and posterior tibioperoneal trunk at the upper border of POP. The ATA run downwards in between the anterior surface of POP and the posterior surface of tibia. The posterior tibioperoneal trunk run on the posterior surface of the POP.

- The posterior tibioperoneal trunk divides into the PRA and PTA distal to the tendinous arch of the soleus muscle.

Trotter et al [73](1940) reported 6.2% of HDPA in 264 specimens.

Keen at al [25](1961) observed 5% of HDPA in 280 specimens.

Bardsley et al[3] (1970) reported 5.9% of HDPA in their angiographic study.

Kim et al[28] (1989) studied 1000 femoral angiogram and reported 4.6% HDPA.

Mauro et al[35] (1988) studied 421 lower extremity angiogram and reported 2.3% of HDPA.

Colborn et al[9] (1994) dissected 42 specimens and reported 7% of HDPA.

Somayaji et al[67] (1996) dissected 250 lowerlimbs and observed HDPA in 25 specimens(10%).

Tindall et al[72] (2006) in doppler study of 100 patients, he observed 6% of HDPA.

Catagay barut et al[4] (2009) reported 3.57% of HDPA in 28 specimens.

Mavilli E et al[36] (2011) in his angiographic study of 535 extremities observed 5.6% of HDPA.

Singla et al[63] (2012) reported 3.3% of HDPA in 60 specimens.

S P Sawant et al[70](2013) and reported 13.3% of ATA arising from PA proximal to POP and travelled posterior to popliteal muscle.

P B Billakanti et al[7](2014): In his routine cadaveric study , reported HDPA in one cadaver on right side.

Ankit Khandelwal[26] (2014) reported 5% of HDPA in 40 specimens.

Oztekin et al[43] (2015) reported one case of HDPA out of 495 extremities (0.2%).

Hema et al[22](2016)observed 7.5% of HDPA out of 40 extremities.

7. TRIFURCATION OF POPLITEAL ARTERY

Quain[50] (1844) observed 2.3% of trifurcation in 258 specimens.

Adachi[1] (1928) stated that when all three terminal branches arise together at the level of lower border of the POP, it can be considered as trifurcation. He observed 0.8% of trifurcation in 770 specimens.

Trotter et al[73] (1940) reported 0.5% trifurcation in 1168 specimens.

Keen et al[25](1961) observed 4.3% trifurcation in 280 specimens.

Morris et al [39](1961) observed 2.9% trifurcation in 246 femoral angiograms.

Bardsley et al[3](1970) stated that in 235 specimens, 0.4% of trifurcation was observed.

Lippert et al[33] (1985) reported 4% of trifurcation in his study.

Kim et al [28](1989) dissected 605 specimens and observed 2% of trifurcation.

Mauro et al[35] (1989) studied 343 angiograms and noted 4.1% of trifurcation.

Neville et al[41] (1990) reported 1.9% trifurcation in study of 4108 lower limb specimens.

Ozgur et al[42] (2009) reported 2.5% trifurcation

S W Kil et al[27](2009) noted 1.5% trifurcation.

Mavilli Eet al[36](2011) in his angiographic study of 535 extremities reported 5.4% of Trifurcation.

Sawant et al [70](2013) dissected 120 specimens and reported 5% of trifurcation

Oztekin et al[43] (2015) reported trifurcations in 3 specimens out of 495 extremities (0.6%).

Krysztof et al[30] (2016) in his study observed 2.4% out of 12,757 lower limbs.

Hema et al [22](2016) dissected 40 lower limbs and reported 5%of trifurcation.

8. HIGH ORIGIN ANTERIOR TIBIAL ARTERY

High origin of ATA lying posterior to the popliteus muscle is the most common type in HDPA.

8A. HIGH ORIGIN ANTERIOR TIBIAL ARTERY LYING POSTERIOR TO POPLITEUS MUSCLE

Parson and Robinson[44] (1898) reported high origin ATA in 5.6%out of 106 specimens .

Adachi[1] (1928) observed high origin ATA in 1.9% of total 770 specimens.

Trotter et al[73] (1940) reported 3.9% of high origin ATA in 1168 specimens.

Keen et al[25] (1961) stated 4% of high origin ATA in 280 specimens observed.

Lippert et al[33](1985) observed 4% of high origin ATA in their cadaveric studies.

Kim et al[28] (1989) observed 3.7% of high origin ATA in angiographic study of 605 lower limbs.

Colborn et al[9] (1994) reported high origin ATA in 3 out of 42 cadavers (7%).

Somayaji et al[67] (1996) reported 6.4% of high origin ATA in total 25 specimens.

Day et al[12] (2006) in his study reported 4.5% of high origin ATA in 1037 lower limbs.

Ozgur et al[42] (2009) observed high origin ATA in 2 specimens out of 40 lower limb specimens (5%).

Singla et al[63] (2012) reported 3.3% high origin ATA in 60 specimens.

Sawant et al[70] (2013) observed 4 high origin ATA out of 120 specimens (3.33%).

8B. HIGH ORIGIN OF ANTERIOR TIBIAL ARTERY LYING ANTERIOR TO POPLITEUS MUSCLE

Parson and Robinson[44] (1898) reported high origin of ATA in 2 cadavers out of 106 specimens (2%).

Adachi [1](1928) observed 1% of high origin ATA in total 770 specimens.

Trotter et al[73](1940) reported 2.4% of high origin ATA in 1168 specimens.

Keen et al [25](1961) noted 0.4% of high origin ATA in 280 specimens.

Lippert et al[33](1985) observed 1% of high origin ATA in their cadaveric studies.

Kim et al[28] (1989) observed 0.7% of high origin ATA in angiographic study of 605 lower limbs.

Colborn et al[9] (1994) reported high origin ATA in 1 out of 42 cadavers (2.3%).

Somayaji et al[67] (1996) reported 0.4% of high origin ATA in total 25 specimens.

Singla et al[63] (2012) reported nil high origin ATA in 60 specimens.

Sawant et al[70] (2013) observed 10 high origin ATA out of 120 specimens (8.33%).

8C. HIGH ORIGIN OF POSTERIOR TIBIAL ARTERY

Adachi[1] (1928) reported high origin PTA in 0.8% of total 770 specimens.

Morris et al [38](1961) observed 0.8% of high origin PTA.

Trotter et al[73] (1940) reported 1.4%of high origin PTA in 1168 specimens**.**

Keen et al[25](1961)reported 1.1% of high origin PTA in 280 specimens.

Lippert et al[33] (1985) observed 1% of high origin PTA in their cadaveric studies.

Mauro et al[35] (1961) reported 0.9% of high origin PTA

Bardsley[3] (1970) found 1.7% high origin PTA in 235 specimens.

Kim et al[28] (1989) observed 0.8% of high origin PTA in angiographic study of 605 lower limbs.

S P Sawant et al[70] (2012) During routine dissection reported a high origin of PTA from left side lower limb. The PTA run downwards on the posterior surface

of the POP. The anterior tibioperoneal trunk distal to the tendinous arch of soleus muscle divides into the anterior tibial and the peroneal arteries. The further course of anterior, posterior tibial and peroneal arteries were normal.

9. ORIGIN OF PERONEAL ARTERY FROM ANTERIOR TIBIAL ARTERY

Keen at al[25](1961) observed origin of PRA from ATA in 3 out of 280 specimen (1%).

Kanagasunderam R et al (1987) ATA and PTA starts about 5 cm below knee joint and PRA arises 7.5cm below knee joint.

Berish strauch et al[6] (1993) studied the course of PRA and stated that it arises from PTA about 3 cm below the lower border of POP. He also classified the variations of the PRA as following:

- Type A-PRA arises from the PTA in 90% of cases.
- Type B-PRA arises from ATA in 1% cases.
- Type C-PRA arises from PA in 1% cases.
- Type D-PRA replaces PTA in 8% cases.

Colborn et al [9](1994) observed the origin of PRA from ATA in 3 out of 42 cadavers (7%).

Poratt D et al[48] (1994) reported a case in which the PRA had replaced hypoplastic PTA.

Renan et al[51] (1997) reported that the PRA originates within 1cm of PTA and may arise directly from PA.

Singla et al[63] (2012) reported origin of PRA from ATA in 1out of 60 specimens (1.6%).

Sawant et al[70] (2013) observed the origin of PRA from ATA 4out of 120 specimens.

10. RELATION OF POPLITEAL ARTERY TO POPLITEAL VEIN AND TIBIAL NERVE

Ronano'Rahilly[53](1986) has stated that PTA begins at the lower border of popliteus. TN is related medial, posterior, and lateral to the artery, above downwards. If the ATA is small or absent, the PRA is larger. Perforating branch of PRA replaces the dorsalis pedis artery.

G.J.Romanes[55] (1996) mentioned that the superficial relation to PA are semimembranosus, the PV, TN , gastrocnemius and plantaris.

Cornelius Rosse and Penelope Gaddum Rosse[10] (1997): Deeper in the popliteal fossa is the PA. The PV is superficial to it.

Arthur F Dalley[2] (2006): The PV lying superficial to the PA and are enclosed in the same fibrous sheath.

A.Halim[19] (2008): TN and PV lies superficial to the PA. The TN crosses the popliteal vessels from lateral to medial side as it courses downwards.

D.K. Kadasne[24] (2009) stated that the PV follow the artery, but lies superficial to it and the TN lies superficial to artery and vein.

Anne M. R. Agur[2] (2009) The TN is superficial to the PV, which in turn is superficial to the artery.

Richard S. Snell[66] (2010) reported that the TN crosses the PA from lateral to medial side. The PV lies superficial to the PA.

Chummy S. Sinnatamby[64] (2011) mentioned that throughout the popliteal fossa, the PA is deepest of large neurovascular structures in the popliteal fossa. At all levels PV lies between the artery and nerve.

Susan Standring- Gray's Anatomy[69] (2012) stated that PA crossed from its lateral to medial side by TN. The PV lies between TN and PA. The PV is usually superficial and adjacent to the PA. The vein may be separated from the artery by a slip of muscle derived from the medial head of gastrocnemius.

Embryology

EMBRYOLOGY

The lower extremity blood supply is detectable in the 9 mm embryo. The sciatic artery also referred to as the ischiatic or axial artery[61], is a branch of the internal iliac artery and it is the major supply to the early developing limb bud. By 14 mm embryo stage, the FA a branch of the external iliac artery, has anastomosed with sciatic artery and become the major supply vessel to the lower limb.

The more proximal sciatic artery regresses to be represented by the inferior gluteal artery and artery to sciatic nerve in the adult. The primitive middle and distal sciatic arterial segments persist to form the definitive popliteal and peroneal arteries.

The anterior tibial artery arises as a branch of the PA and initially runs anterior to the popliteus muscle. This is the usual primate anatomy. In humans, the early anterior tibial artery is replaced by a superficial PA that passes posteriorly(superficially) to the popliteus muscle, which then gives rise to the definitive ATA.

The PTA is formed by an anastomosis between the early distal FA and the popliteal artery. The definitive anatomy is completed by 3 months of gestation.

The embryonic vascular development determines the anatomical variability. Thus, embryonic vessels may either persist or degenerate or abnormal fusion may occur. Most of the variations can be explained by combination of persistent primitive arterial segment, abnormal fusion or segmental hypoplasia or absence. In adults, the remnants of the axis artery(**Susan standring**)[69] are

1. The inferior gluteal artery
2. Arteria comitans nervi ischiadici
3. Longitudinal anastomosis of the perforating branches of the profunda femoris artery.
4. Part of the PRA
5. Part of the plantar arch.

Understanding the embryology and variant anatomy, may have significant clinical implications.Variations in the branching pattern of PA will influence the surgical approach and choice of suitable arterial graft sites.

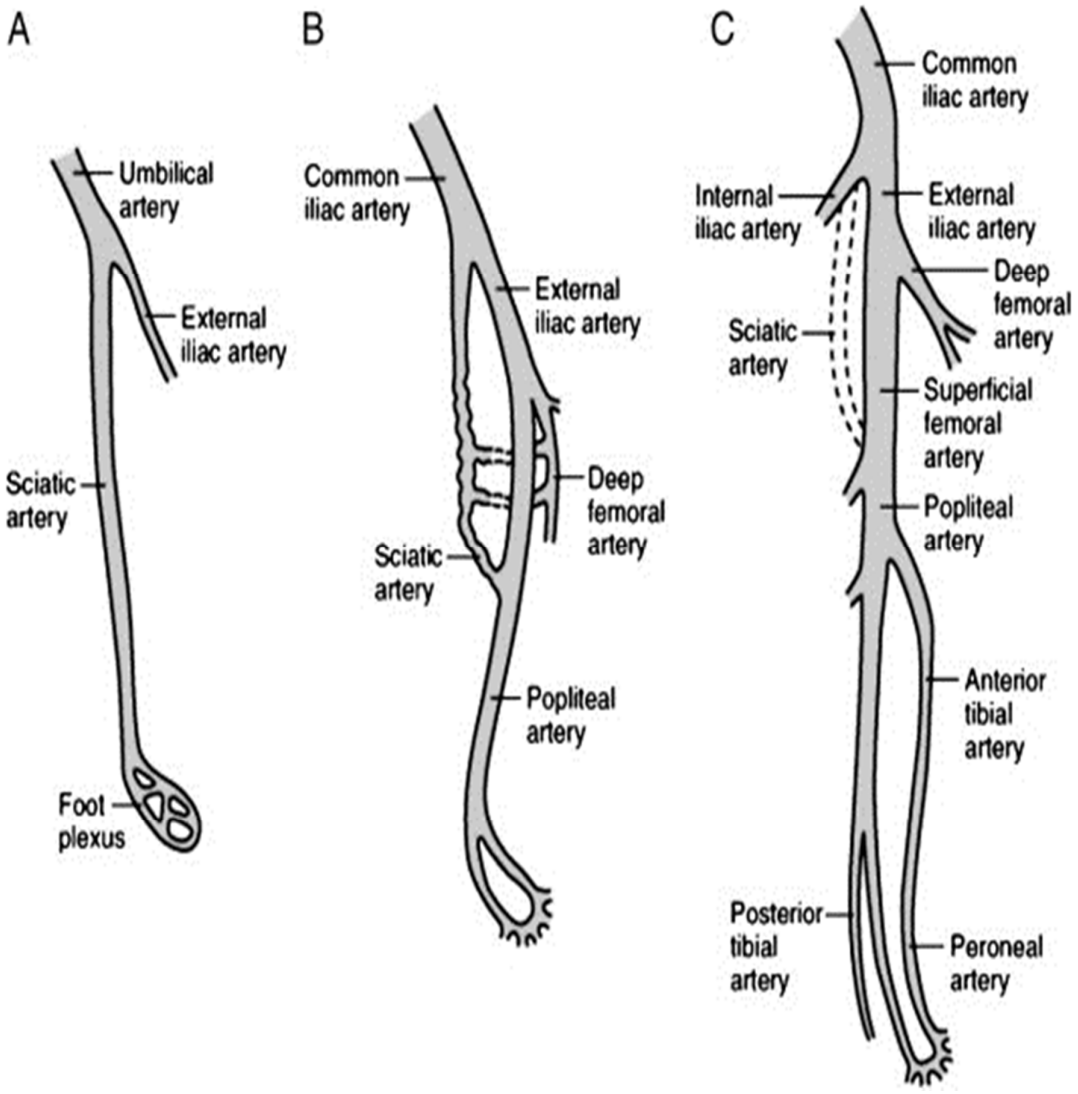


Figure : Stages of development of popliteal artery

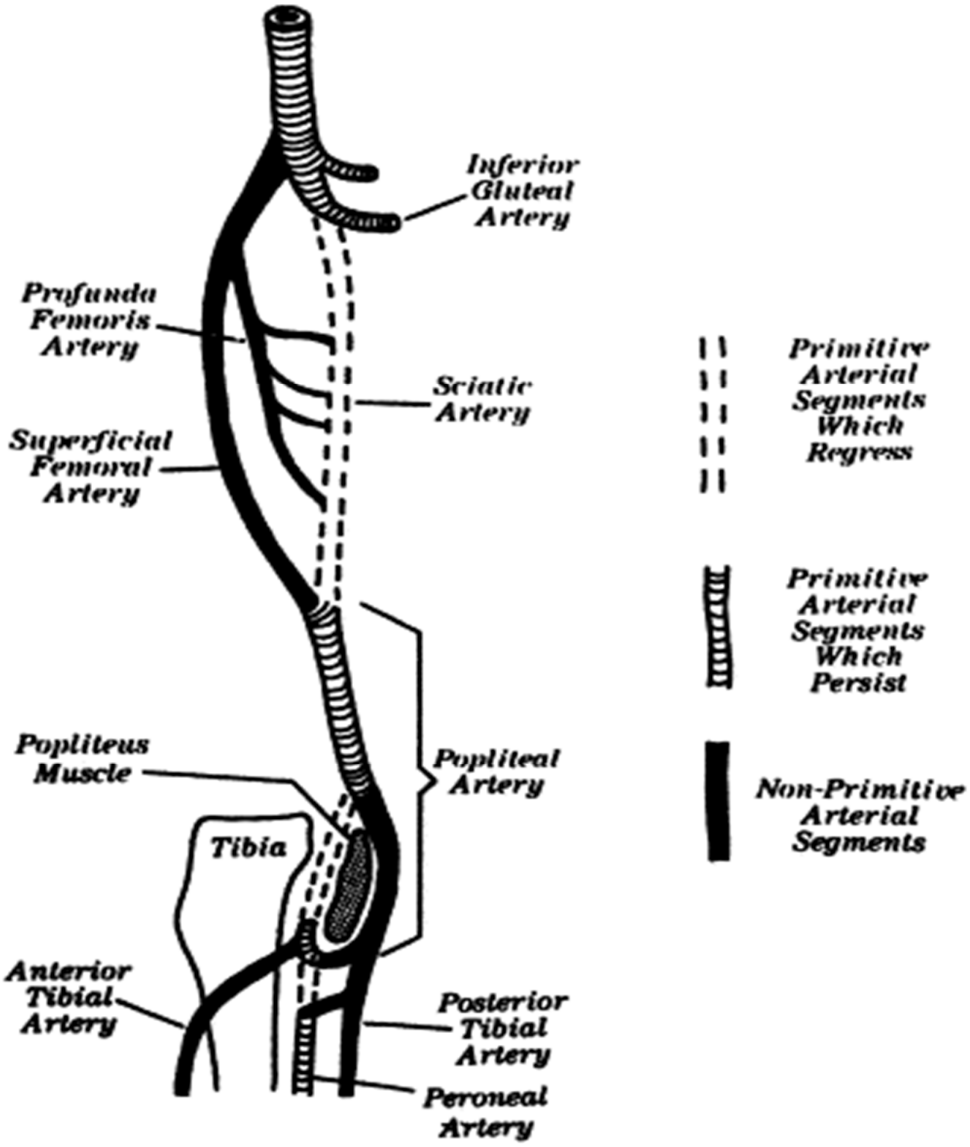
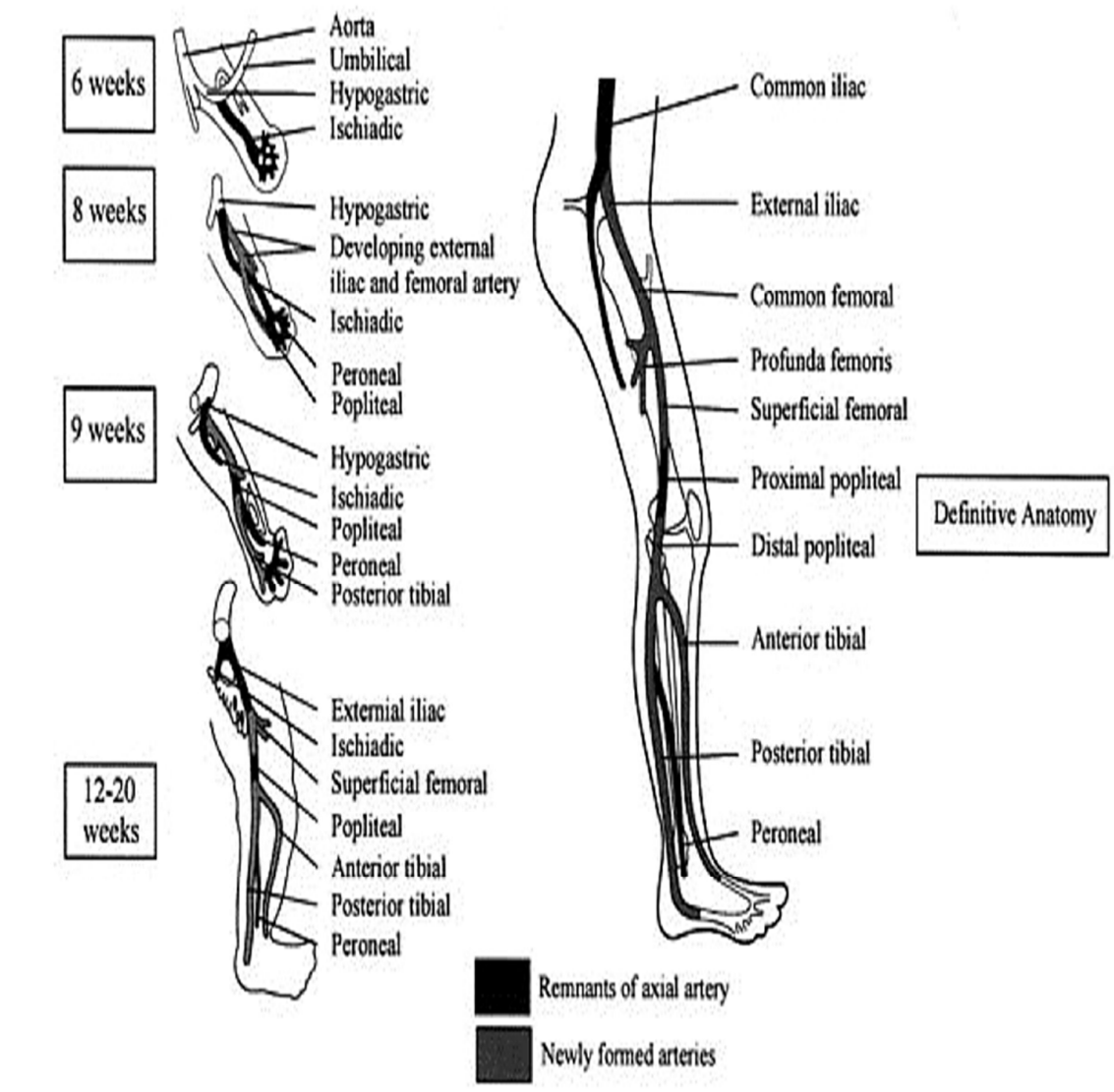


Figure : Embryological development of popliteal artery


6 weeks
Aorta
Umbilical
Hypogastric
Ischiadic
8 weeks
Hypogastric
Developing external iliac and femoral artery
Ischiadic
Peroneal
Popliteal
9 weeks
Hypogastric
Ischiadic
Popliteal
Peroneal
Posterior tibial
12-20 weeks
External iliac
Ischiadic
Superficial femoral
Popliteal
Anterior tibial
Posterior tibial
Peroneal
Common iliac
External iliac
Common femoral
Profunda femoris
Superficial femoral
Proximal popliteal
Distal popliteal
Anterior tibial
Posterior tibial
Peroneal
Definitive Anatomy
Remnants of axial artery
Newly formed arteries

Materials and methods

MATERIALS AND METHODS

STUDY MATERIALS

50 Embalmed human adult lower limb specimens

METHOD OF STUDY

Conventional dissection method

SPECIMEN COLLECTION

Adult lower limb specimens were obtained from the embalmed cadavers allotted for routine dissection to the first year MBBS and BDS students at the Institute of Anatomy, Madras Medical College, Chennai.

CONVENTIONAL DISSECTION METHOD

Popliteal fossa was dissected as per the dissection steps given in Cunningham textbook of anatomy. A Transverse incision was made at the junction of middle and lower 1/3 of thigh and another transverse incision made at the junction of middle and lower 1/3 of back of leg. A vertical incision connecting the midpoints of the above two transverse incisions was made. Skin flap raised and the superficial fascia was stripped from deep fascia. Cutaneous structures were identified. After reflecting the deep fascia, the boundaries and contents of the popliteal fossa were defined. The two bellies of gastrocnemius were identified and separated from their attachment to the femur. Both bellies of the gastrocnemius were reflected downwards. The lower part of the popliteal vessels

and the TN in the popliteal fossa were exposed. The soleus was separated from its tibial attachment and reflected laterally along with the intermuscular septum. The lower border of the popliteus was identified. The fascia was removed from the popliteal vessels and the terminal branches namely the anterior tibial and posterior tibial arteries were traced. ATA gives off at this level from PA and extends into the anterior compartment of leg. The PTA was traced upto the flexor retinaculum. The PRA was identified which arose from the PTA and traced along the back of the fibula undercover of flexor hallucis longus muscle.

The large muscular branches of the PA were exposed and traced further. After removing the fat from the popliteal surface of the femur, the lateral, medial and middle genicular branches were identified and traced. The following parameters were noted after dissection :

- The length of the PA was measured from its origin (hiatus of the adductor magnus) to the level of terminal division using a thread and scale.
- The diameter of the PA was measured using vernier calipers at the three different levels.(AH, level of bifurcation, midpoint)
- Variations in the terminal branching pattern of popliteal arteries were noted.

Observation

OBSERVATION

1. ORIGIN OF POPLITEAL ARTERY

Of the fifty lower limb specimens dissected, in all the specimens (100 %) the PA was the continuation from FA (Table No. 1).

Table No: 1 Origin of Popliteal Artery

S. No	Origin of PA	Frequency (n=50)	Percentage (%)
1	From femoral artery	50	100
2	Other source of origin	-	-

Chart No: 1 Origin of Popliteal Artery

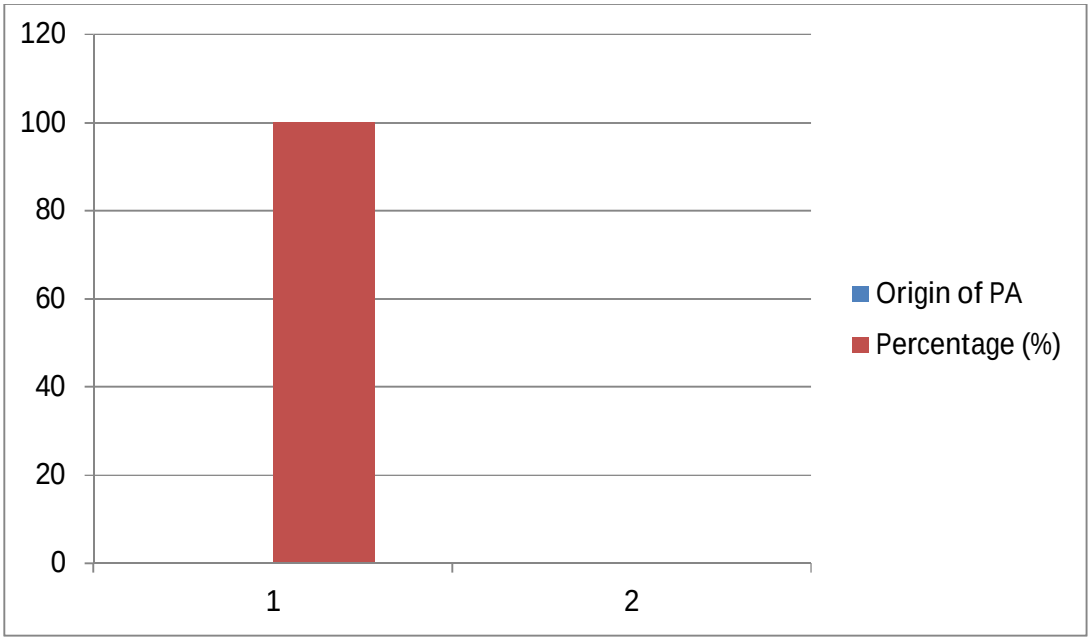
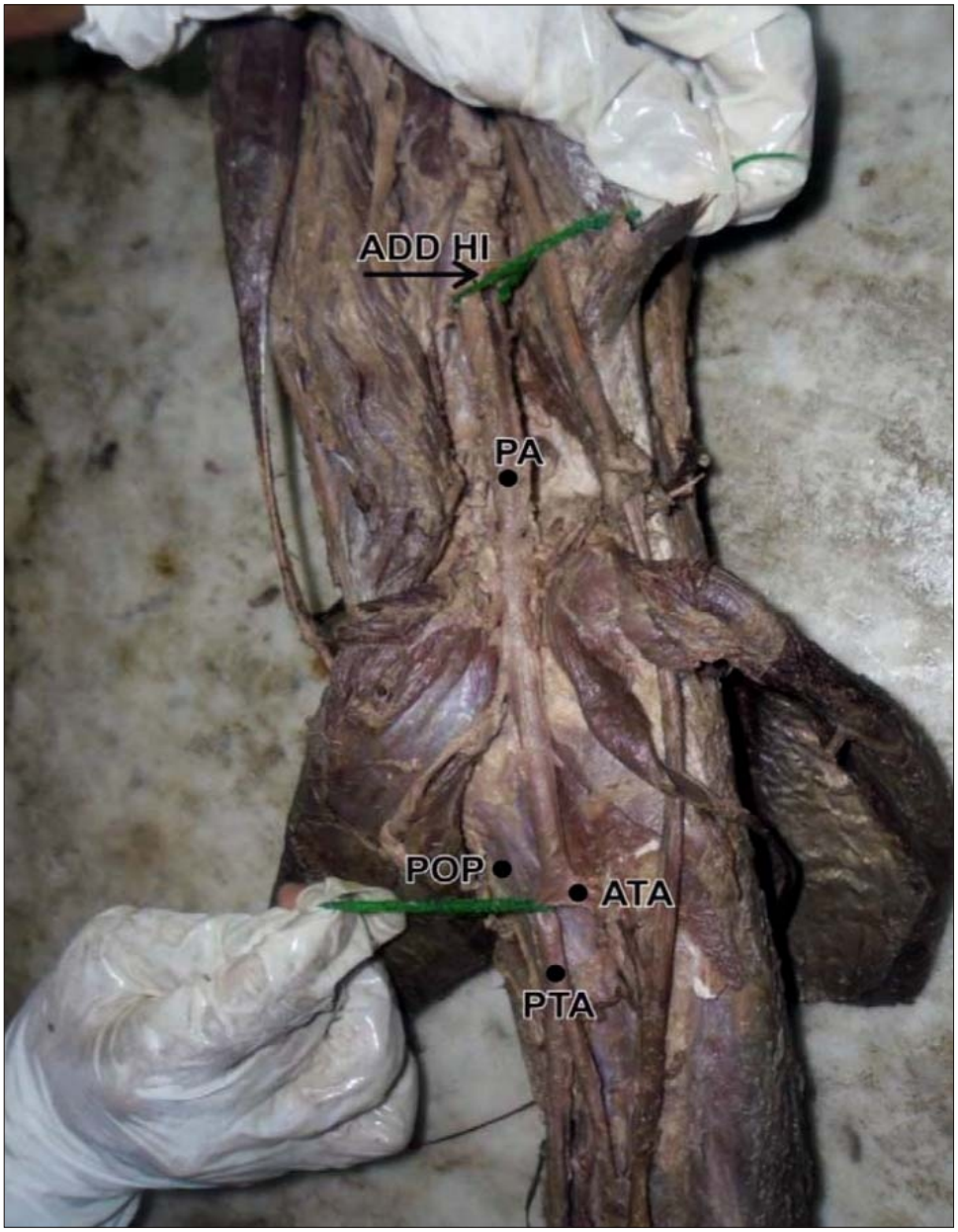


Fig 1 : Normal course of popliteal artery



AH - Adductor Hiatus, **PA - Popliteal artery**
POP - Popliteus muscle, **ATA - Anterior tibial artery**
PTA - Posterior tibial artery

2. COURSE OF THE POPLITEAL ARTERY

In all the dissected specimens the course of PA was found to be normal (Figure 1)

3. LENGTH OF POLITEAL ARTERY

The length of the PA is measured from AH to the level of bifurcation into ATA and PTA.

The minimum length of PA was 16.7 cm, the maximum length of PA was observed to be 20.5 cm and the mean length was 18.6 cm (Table No. 2).

Table No.2 - Length of Popliteal Artery

Minimum length	16.7 cm
Maximum length	20.5 cm
Mean length	18.6 cm

Chart No: 2 Length of the Popliteal Artery

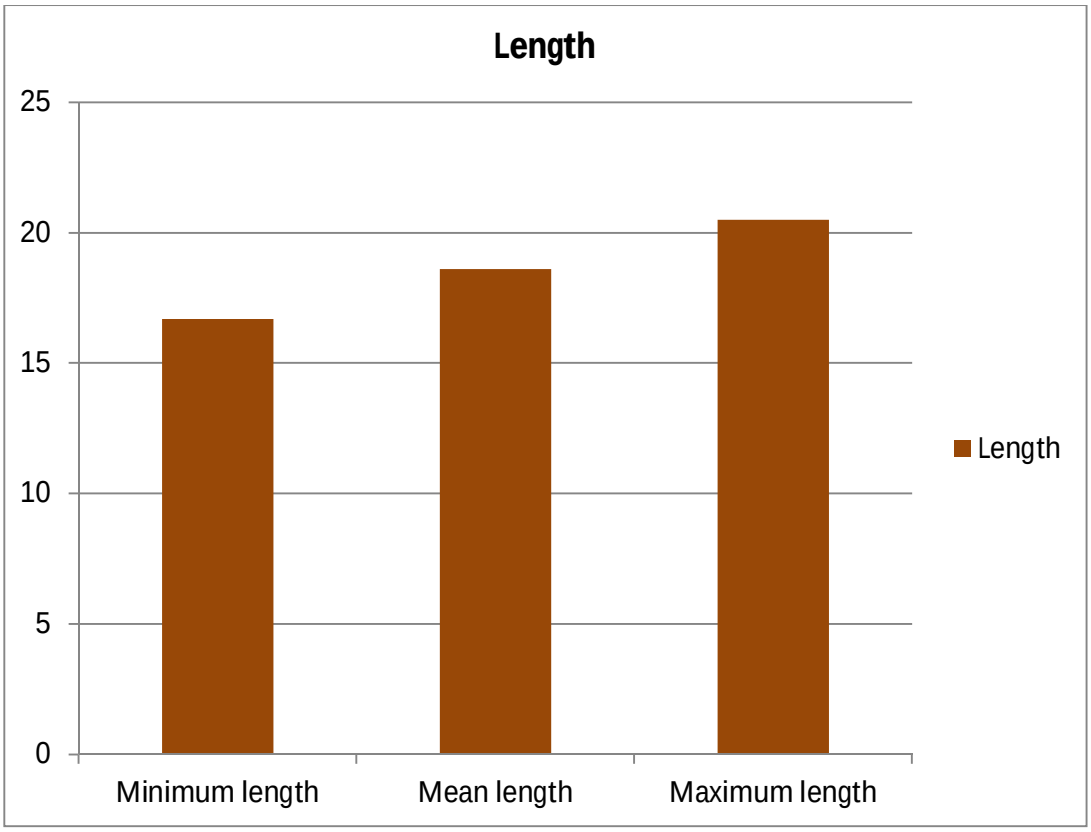


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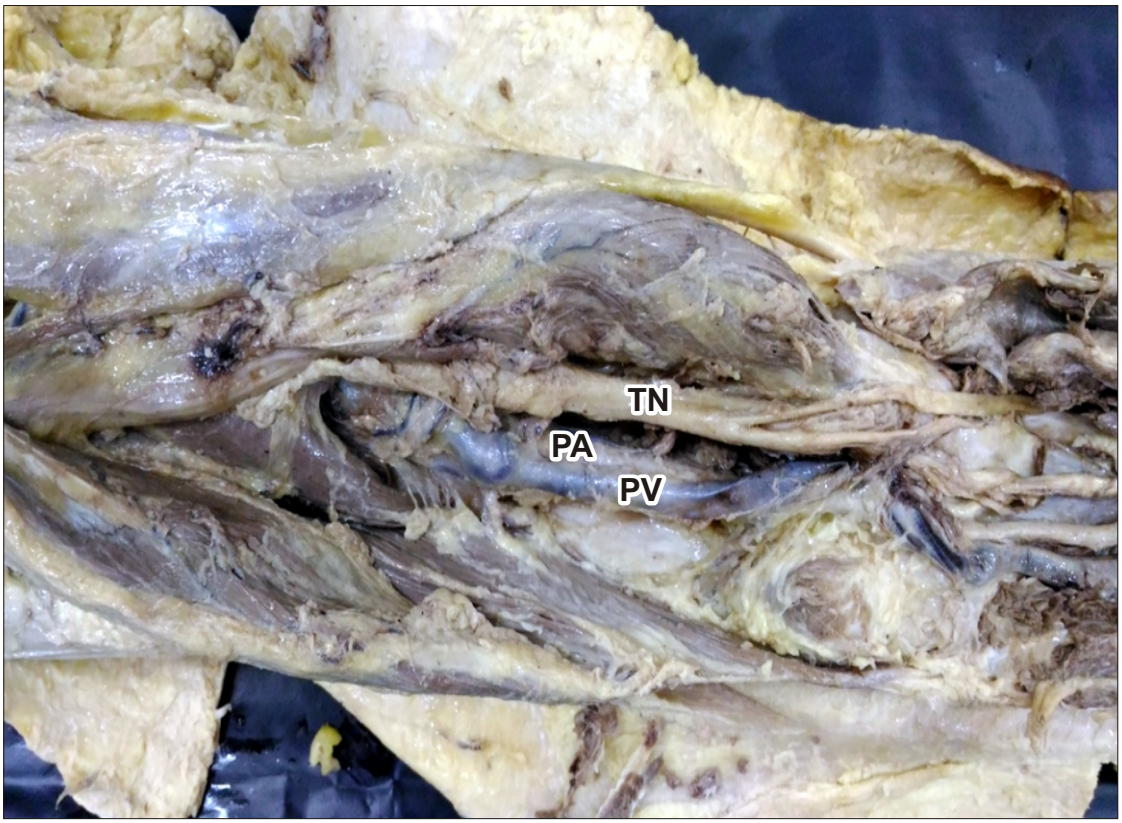
Fig 2 : Normal relation of popliteal artery to Adjacent Neurovascular System



TN - Tibial nerve PA - Popliteal artery PV - Popliteal vein

4. DIAMETER OF THE POPLITEAL ARTERY

The diameter was measured using standard vernier calipers and the results are given in millimeters.

In the present study the minimum diameter of the popliteal artery was observed to be 6.8 mm, maximum diameter was 8.8 mm and the average diameter was 7.8 mm (Table No 3)

Table No. 3 – Diameter of the Popliteal Artery

Minimum diameter	6.8 mm
Maximum diameter	8.8 mm
Average diameter	7.8 mm

Chart No: 3 Diameter of the Popliteal Artery

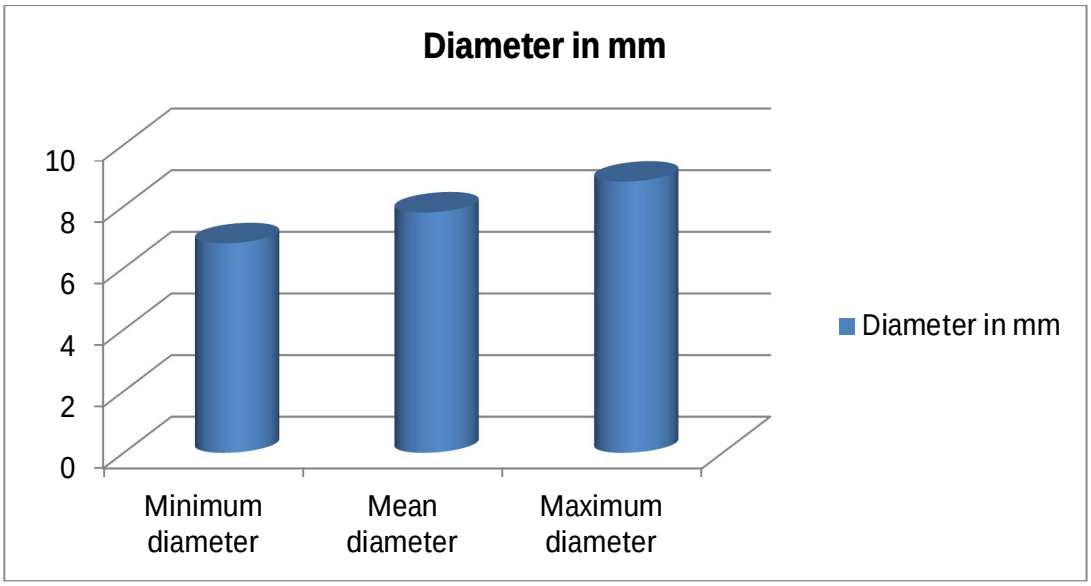
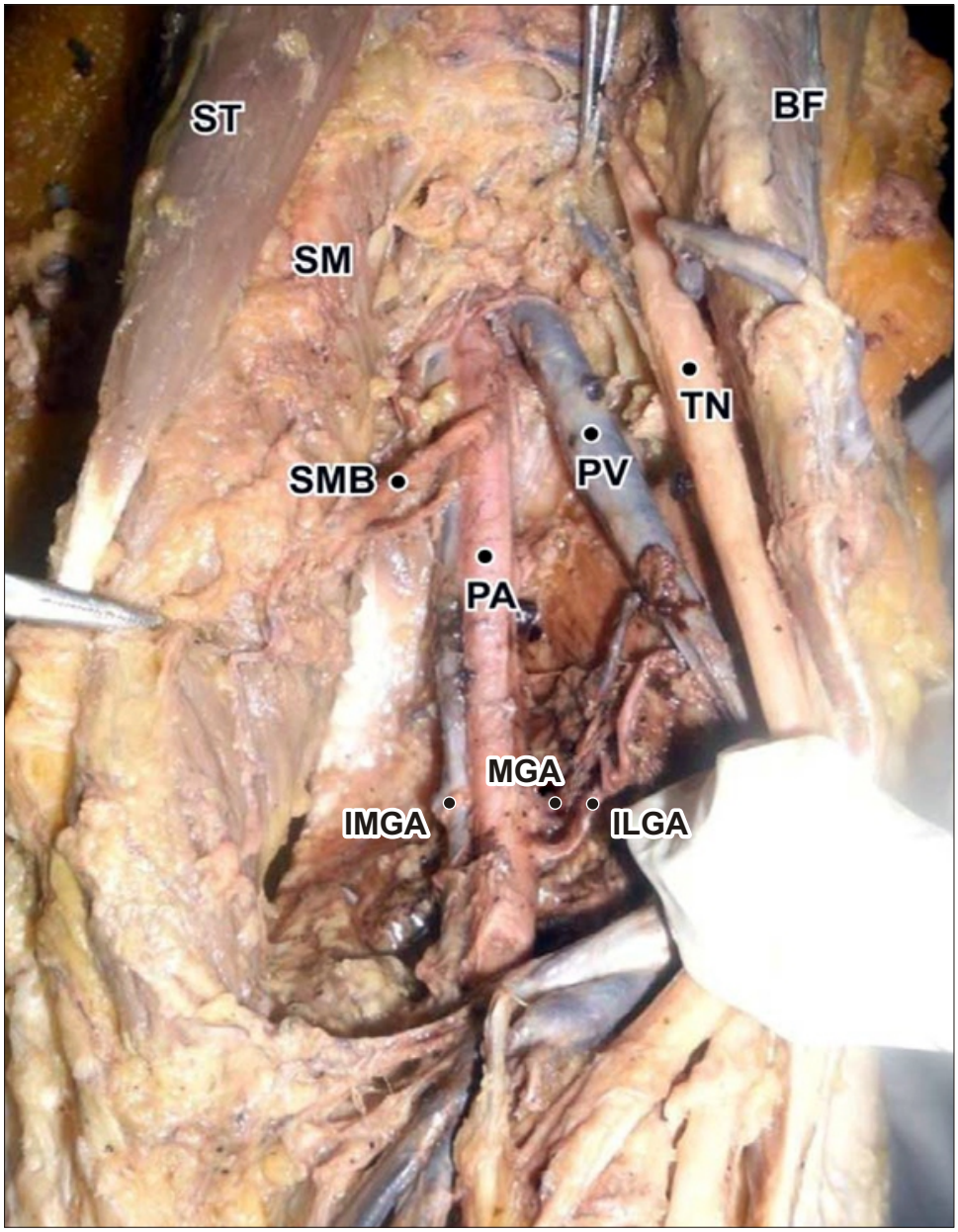


Fig 3 : Genicular Branches



ST - Semitendinous, SM - Semimembranosus, BF - Biceps femoris
TN - Tibial nerve, PV - Popliteal vein, PA - Popliteal artery,
SMGA - Superior Medial genicular artery,
ILGA - Inferior lateral genicular artery
IMGA - Inferior Medial genicular artery,
MGA - Middle genicular artery

5. BRANCHES OF THE POPLITEAL ARTERY

In the present study of fifty lower limb specimens, the muscular branches, genicular branches, cutaneous branches and terminal branches were observed (Table No. 4). Out of the fifty lower limb specimens, one specimen showed ILGA which takes origin from ATA instead of PA (Chart No. 4)

Table No. 4 – Branches of the Popliteal Artery

Branches of Popliteal Artery	Specimens (n=50)	Number (%)
Normal branching pattern from PA	49	98
Origin of ILGA from ATA	1	2

Chart No: 4 - Branches of Popliteal Artery

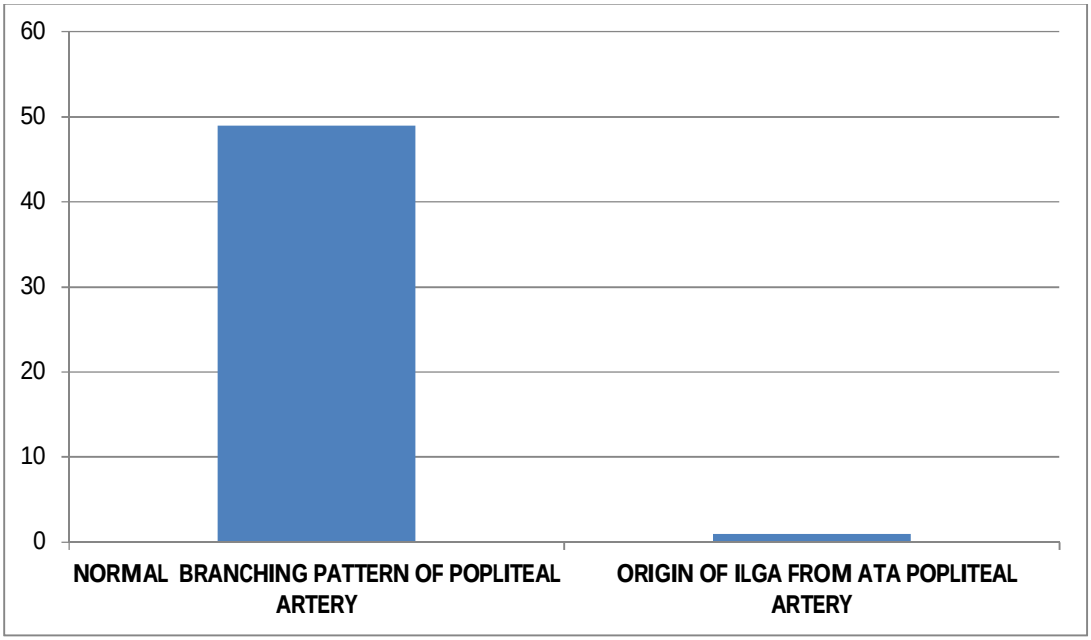
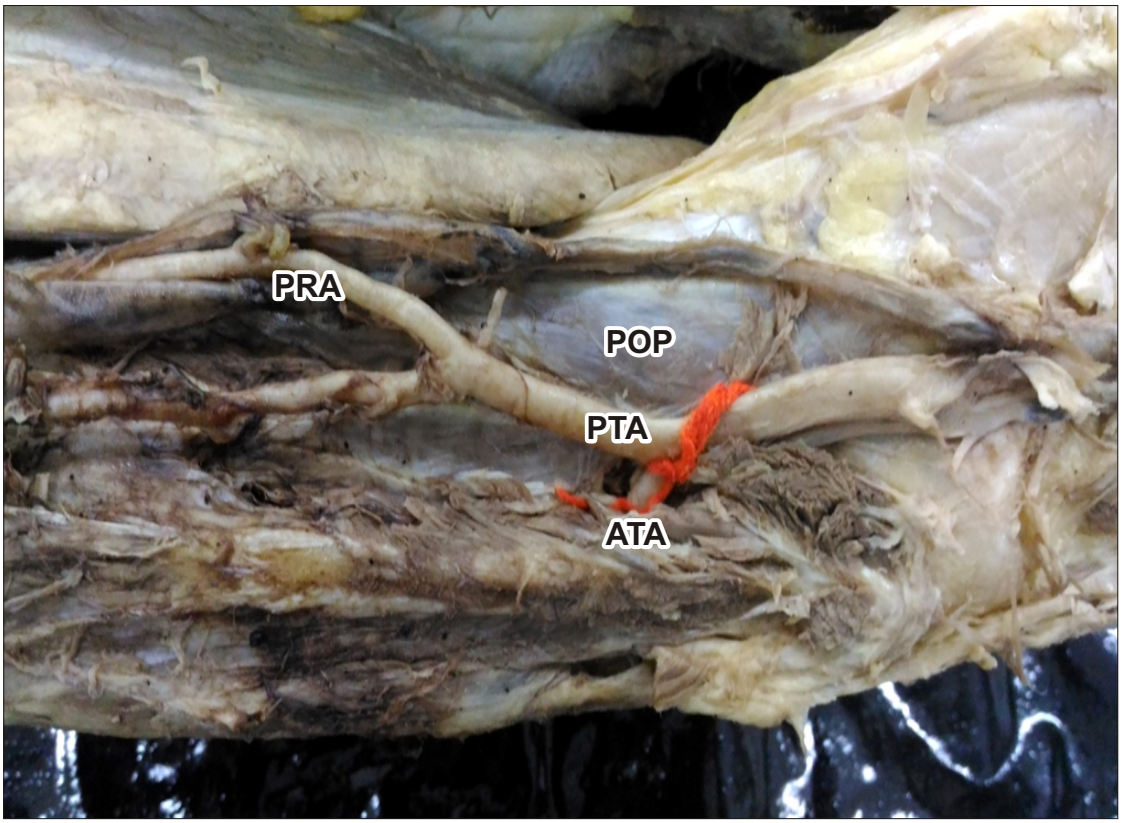


Fig 4 : Terminal division of popliteal artery



POP - Popliteus muscle
PA - Popliteal artery
ATA - Anterior tibilal artery
PTA - Posterior tibial artery
PRA - Peroneal artery

6. TERMINAL DIVISION OF POPLITEAL ARTERY

In the present study, out of fifty specimens, forty eight specimens showed normal pattern of terminal division of PA.

In one specimen, high division of PA was observed.

In another specimen, trifurcation of PA was identified (Table No. 5)

Table No.5 - The variations in the terminal division of popliteal artery

S. No	Termination of Popliteal artery	No. of specimens	Total number of specimens	Percentage (%)
1.	Normal termination of PA	48	50	96
2	High division of PA	1	50	2
3.	Trifurcation of PA	1	50	2

CHART NO 5: Variations in Terminal division of Popliteal Artery

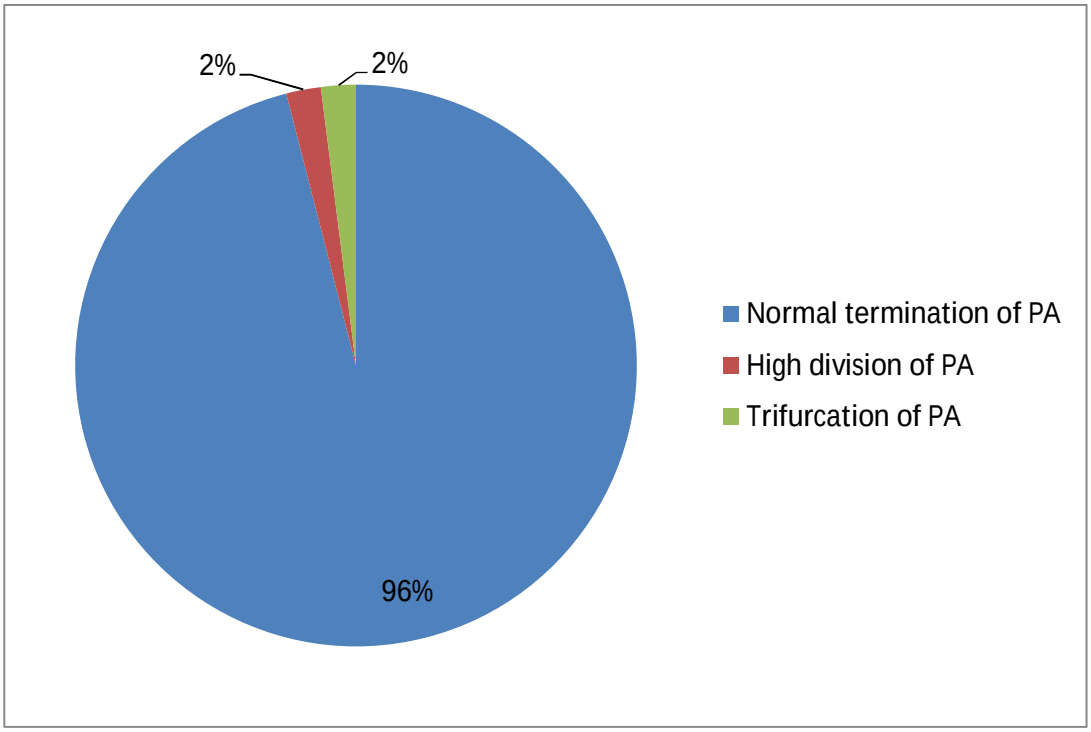
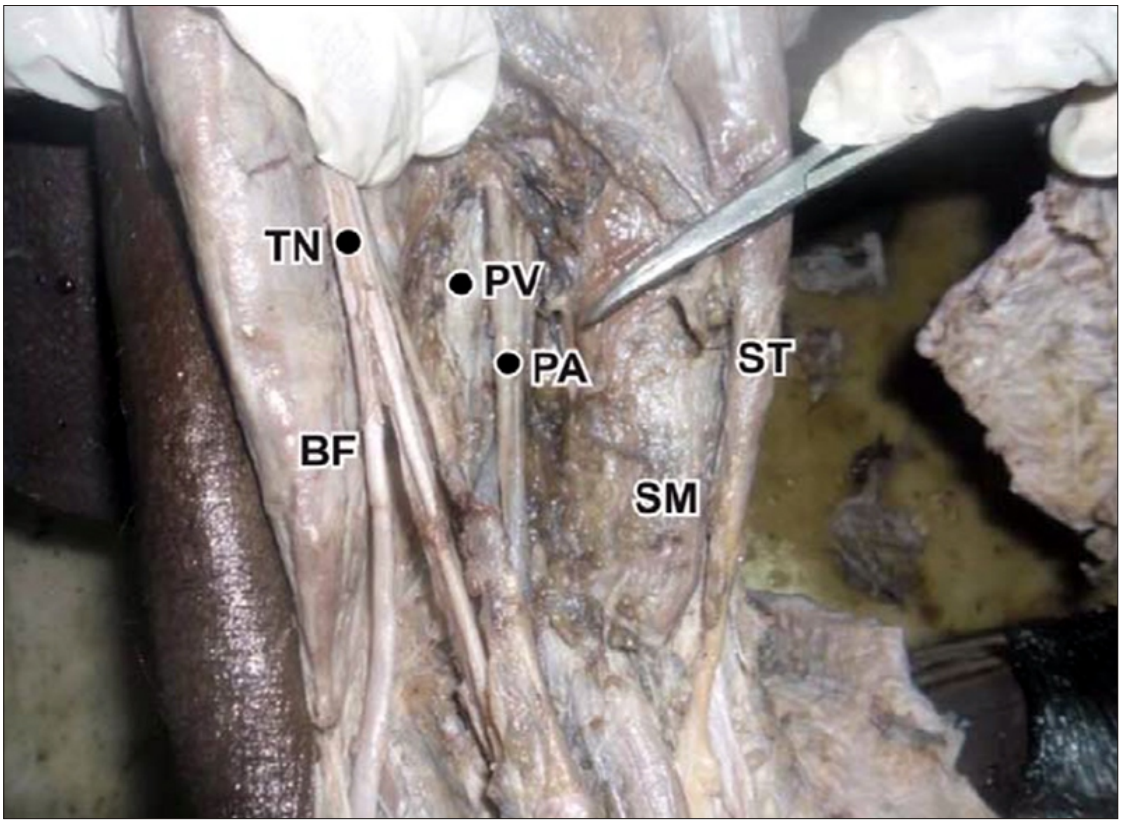


Fig 5 : Abnormal relation of popliteal artery to vein



ST - Semitendinous, SM - Semimembranosus, BF - Biceps femoris
TN - Tibial nerve, PV - Popliteal vein, PA - Popliteal artery

7. RELATIONS OF POPLITEAL ARTERY TO THE ADJACENT NEUROVASCULAR STRUCTURES

In forty nine specimens out of total 50 specimens, the PA passed deep to PV and TN (98%).

In one specimen the PA passed superficial to PV but deep to TN (2%) (Table No. 6).

Table No. 6 – Relations of Popliteal Artery to Popliteal Vein and Tibial Nerve in Popliteal Fossa

S. No.	Relation of popliteal artery to Adjacent structures	Number of specimens	Percentage (%)
1.	Popliteal artery deep to popliteal vein & tibial nerve	49	98
2.	Popliteal artery superficial to popliteal vein &Tibial nerve.	1	2

Chart No. 6: Relations of Popliteal Artery to Popliteal Vein and Tibial Nerve in Popliteal Fossa

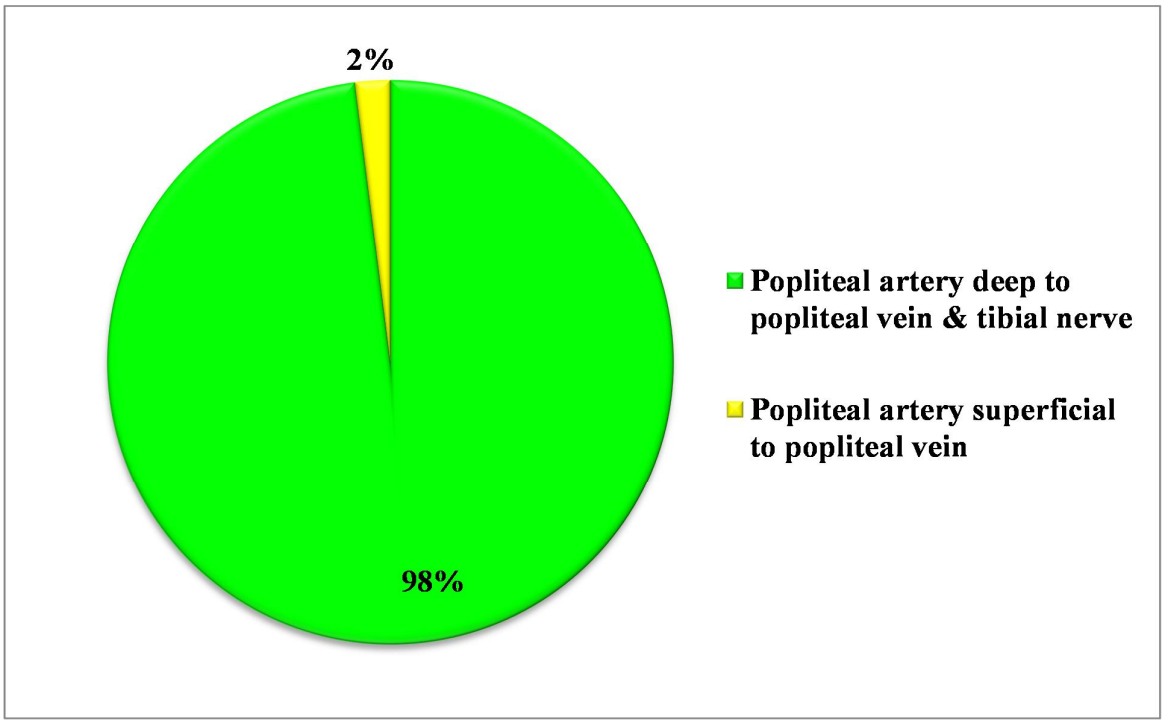
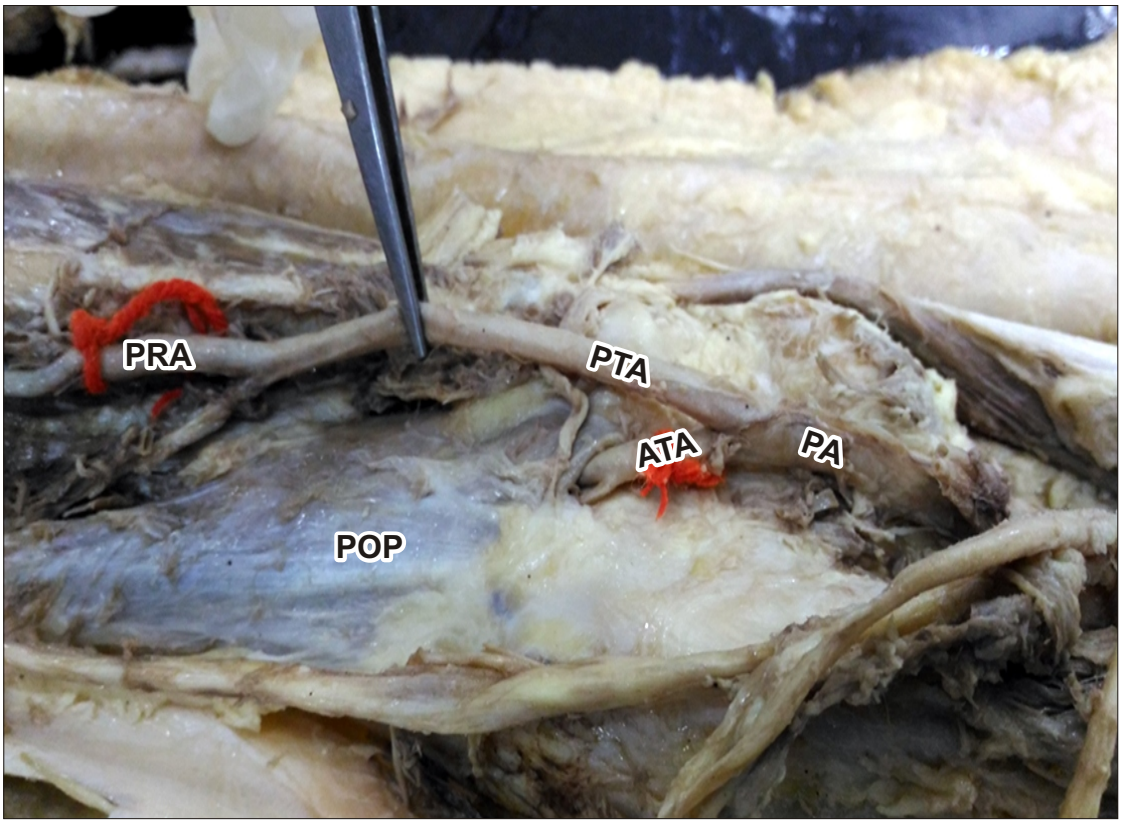


Fig 6 : High division of popliteal artery

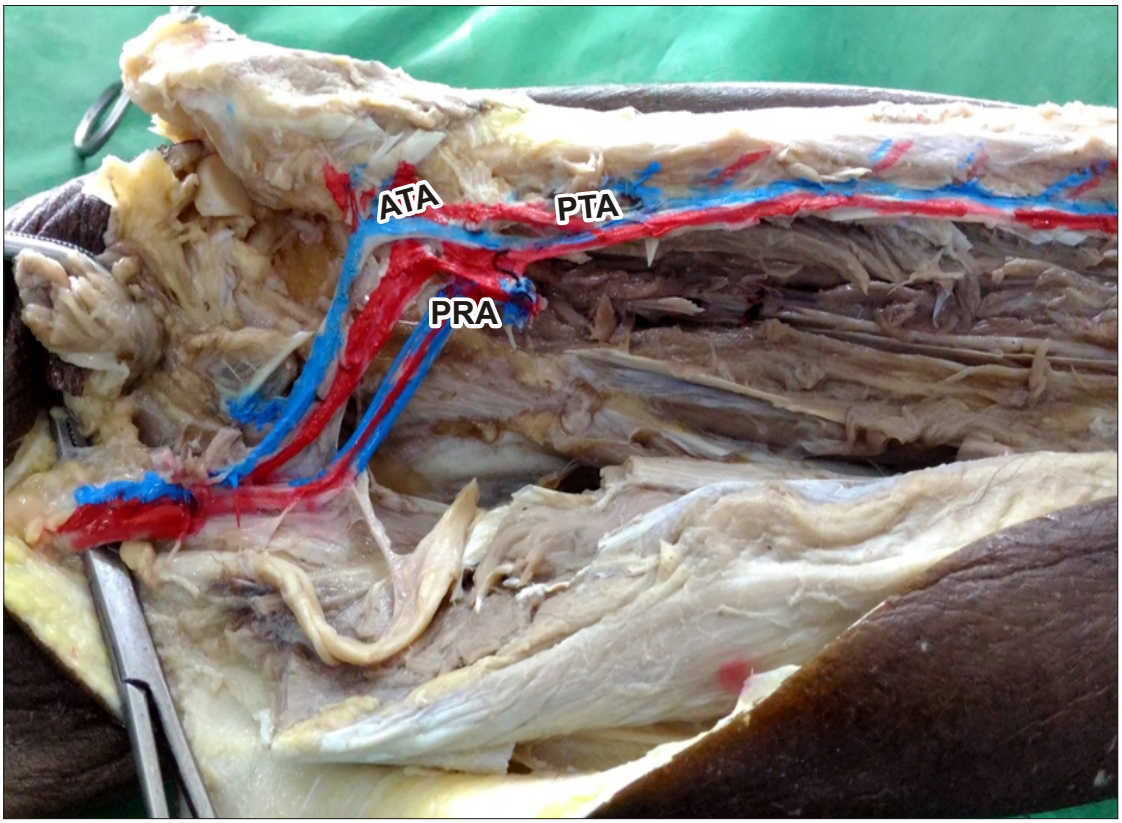


POP - Popliteus muscle **PA - Popliteal artery**

ATA - Anterior tibilal artery **PTA - Posterior tibial artery**

PRA - Peroneal artery

Fig 7 : Trifurcation of popliteal artery

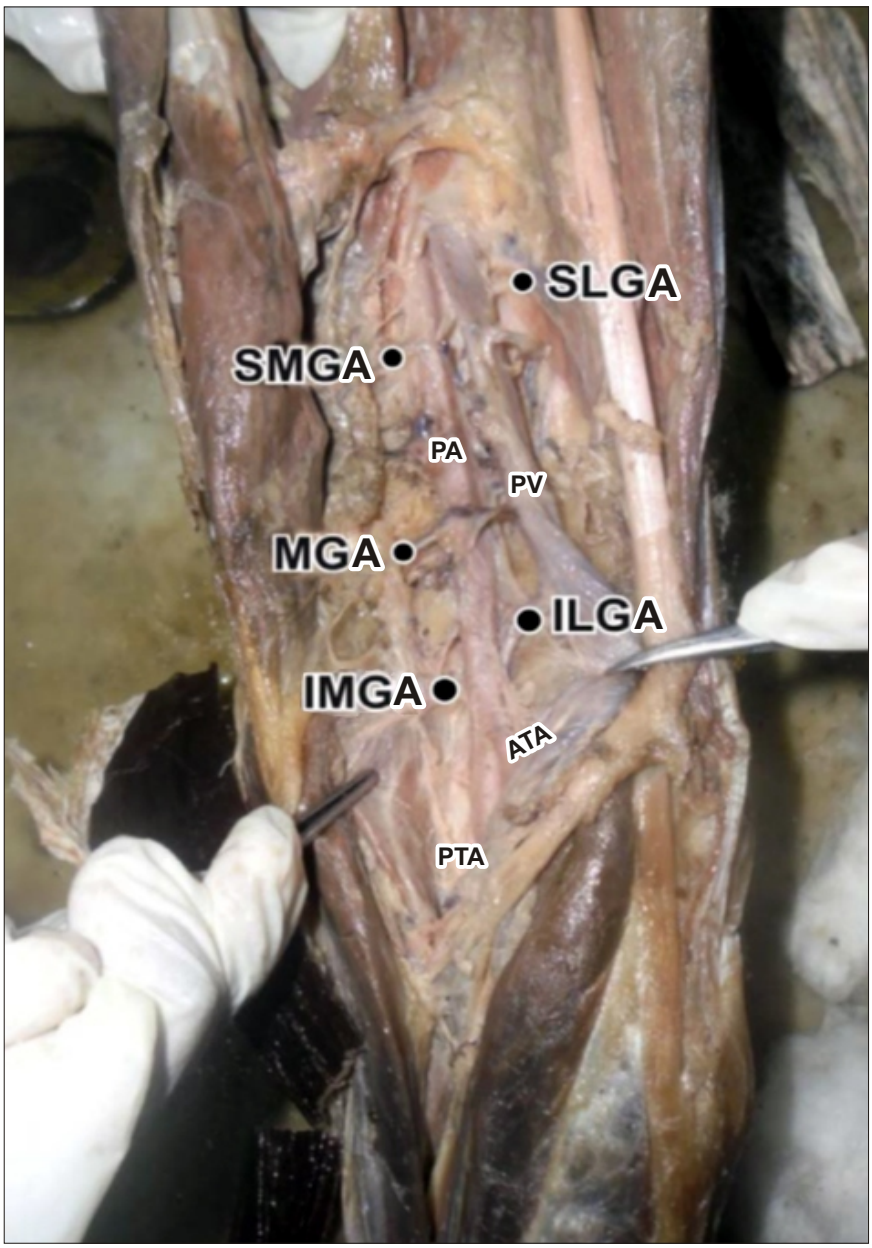


PA - Popliteal artery **PV - Popliteal vein**

ATA - Anterior tibilal artery **PTA - Posterior tibial artery**

PRA - Peroneal artery

Fig 8 : Inferolateral genicular artery arises from ATA



PA - Popliteal artery
SMGA - Superior medial genicular artery
MGA - Middle genicular artery
IMGA - Inferior medial genicular artery
ILGA - Infero lateral genicular artery
SLGA - Superior lateral genicular artery

Discussion

DISCUSSION

1. ORIGIN OF POPLITEAL ARTERY

W. Henry Hollinshead[21] (1969) stated that FA passes through the AH and reaches the posterior aspect of the lower part of the thigh where it is known as PA**.**

Neville RF et al[41] (1990) in their study, reported congenital absence of PA, discovered during operative exploration after a traumatic injury of the lower extremity.

R.J.Last[31] (1999) stated that the PA is the deepest of the neurovascular structures in the fossa. It extends from the hiatus in the adductor magnus to the fibrous arch in the soleus muscle.

D.K.Kadasne[24] (2009) stated that the PA runs as a continuation of FA beyond the opening of artery in adductor magnus.

Richard S. Snell [66](2010) quoted that the PA enters popliteal fossa through the opening in the adductor magnus, as a continuation of FA. It ends at the level of lower border of popliteus into ATA and PTA.

In **Gray's Anatomy[69](2012),** Susan Standring stated that PA is the continuation of FA. Sometimes it may arise as a continuation of the sciatic artery which is a branch of inferior gluteal artery.

The PA may be continuation of the sciatic artery (a branch of the inferior gluteal artery) instead of the FA. When this occurs ,the PA may have an abnormal relationship to popliteus ,running deep to the muscle before dividing into its terminal branches.

2. COURSE OF THE POPLITEAL ARTERY

In all 50 specimens of the present study ,the course of PA was found to be normal.

Sometimes the PA pass medially beneath the medial head of gastrocnemius or may pass beneath an aberrant band of muscle in the popliteal fossa ,contraction of the muscle may occlude the artery .This results in PA entrapment syndrome(PAES).It may cause claudication on exercise in young male patients.

Persistence of the sciatic artery as the major blood supply to the lower extremity in adults is a rare vascular anomaly. Failure to appreciate the persistent sciatic artery as the major inflow into the lower extremity may lead to inappropriate bypass of apparent occlusive disease of the superficial FA. The persistent sciatic artery is may frequently undergo aneurysm, which may lead to critical limb ischemia resulting from thrombosis or embolization of aneurysmal thrombus.

3. LENGTH OF POPLITEAL ARTERY

H.Gaylis et al[17] (1974) in his arteriographic study stated that the average length of the PA was 175 mm.

Ozgur et al[42] (2009) in his study on 40 lower limb specimens obtained from 19 male cadavers and 1female cadaver had measured the length of PA from various anatomical landmarks. They found that the length of PA from the AH to the origin of ATA was 191.1 ± 34.7 mm, from AH to FCs was 138.1 ± 23.8 mm.

Cagatay Barut et al[4] (2009) dissected popliteal fossa in 28 lower limbs specimens for their study. The mean length of the PA from the AH to the FCs was measured as 92.6 ± 16.3 mm on the right side and 100.8 ±21.2 mm on the left side. The mean distance from the FCs to its termination was observed to be 72 ± 19.8 mm in the right side and 66.9 ± 11.5 mm on the left side. Average arterial length from the level of FCs to the site of origin of PRA was 100.1±17.8 mm on right side and 91.8±10.7mm on the left side.

Ankit khandelwal et al[26] (2014) in his study on 40 specimens reported that the average length of PA was observed to be 11.2 cm in contrast to normal length ranging from 18 to 20 cm.

Telang et al[71] (2016) dissected 50 human cadavers and reported that the mean length of PA from apex of AH to the distal edge of FCs was 149.7 mm on the right side and 149.2 mm on the left side, while the mean length of the PA from the distal edge of FCs to its termination was 59.2 mm on the right side and 60.6 mm

on the left side. The mean length of PA from apex of AH to its termination on the right side was 208.7 mm and 208.8 mm on the left side.

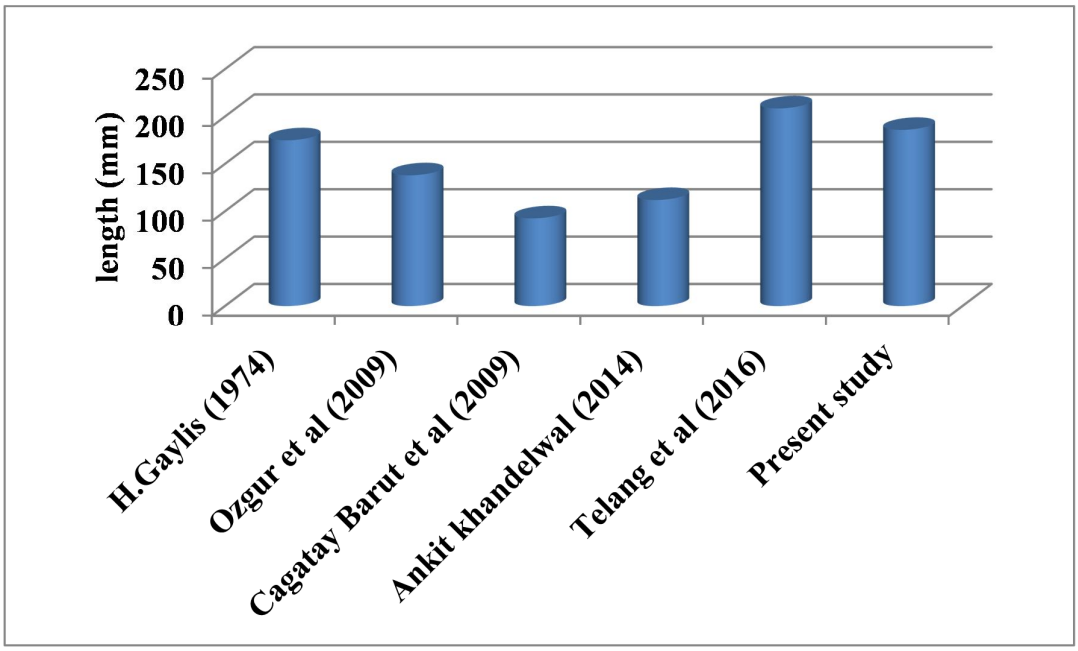
The length of PA form its origin to termination will be helpful for vascular surgeons and radiologist. An understanding of normal anatomy of PA is essential in the surgical management of vascular injuries in the popliteal fossa , surgical endoscopic repair of popliteal aneurysm or femoro-popliteal bypass graft.

In the present study, the mean length of PA from AH to its termination was observed to be 186 mm, which was closer to the report of **H.Gaylis[17] (1974).**

TABLE NO. 7 – MEAN LENGTH OF POPLITEAL ARTERY (MM)

S.No:	Name of the studies	Mean of PA in mm
1.	H.Gaylis (1974)	175
2.	Ozgur et al (2009)	138.1
3.	Cagatay Barut et al (2009)	92.6
4.	Ankit khandelwal (2014)	112
5.	Telang et al (2016)	208.7
6.	**Present study**	**186**

CHART NO. 7 LENGTH OF THE POPLITEAL ARTERY



4. DIAMETER OF THE POPLITEAL ARTERY

Zierler et al [75](1983) stated that the mean diameter of PA is 5.2 ± 1.1 mm

Johnston et al[23] (1991) reported that the mean diameter of PA is 9.0 ± 2.0 mm.

Macchi et al[34] (1994) examined 50 healthy men and women with duplex ultrasound scanning the PA diameter was found to be 5.1 ± 0.4 mm in men, 5.0 ± 0.4 mm in women.

Sandgren et al[59] (1998) screened 121 healthy volunteers and reported mean diameter of PA as 6.9 to 8.4 mm in men and 5.7 to 7.2 mm in women depending on the BSA and age.

In a sonographic study **Crawford et al[11] (1998),** found that the mean PA diameter was 7.2mm and 6.1mm in males and females respectively

Debasso et al[15] (2004) observed 52 healthy men and 56 healthy women and PA diameter was found to be 7.4 mm and 6.3 mm respectively.

Morris-stiff et al [39](2005) screened 449 patients for the presence of PA aneurysm and reported that the mean diameter of PA as 7.4 ± 1.3 mm.

Wolf et al[74] (2006) reported that the measurement of mean PA diameter was 6.8 ± 0.8 mm.

Ozgur et al[42] (2009) dissected 40 specimens and stated that the diameter of PA, 5 cm distal to the AH was 8.2 ± 1.6 mm. The diameter at the level of distal edge of FCs was 7.5 ± 1.3 mm.

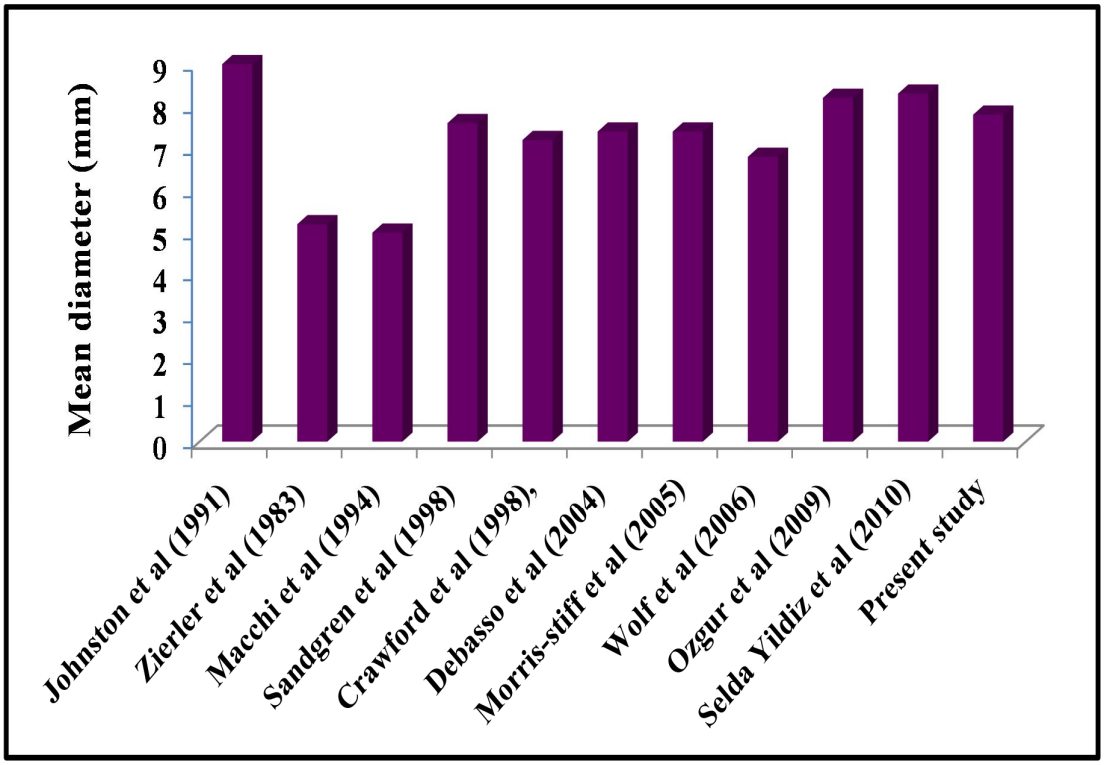
Selda Yildiz et al[60] (2010) in his study said that the mean diameter of PA was 8.3mm.

In the present study the mean diameter of the PA was 7.8 mm closer with the reports of **Ozgur et al[42] (2009), Morris-stiff et al[39] (2005), Debasso et al[15] (2004) and Sandgren et al[59] (1998).**

TABLE NO.8: MEAN DIAMETER OF THE POPLITEAL ARTERY

S. No	Name of the Study	Mean diameter (mm)
1.	Johnston et al (1991)	9
2.	Zierler et al (1983)	5.2
3.	Macchi et al (1994)	5
4.	Sandgren et al (1998)	7.6
5.	Crawford et al (1998),	7.2
6.	Debasso et al (2004)	7.4
7.	Morris-stiff et al (2005)	7.4
8.	Wolf et al (2006)	6.8
9.	Ozgur et al (2009)	8.2
10.	Selda Yildiz et al (2010)	8.3
11.	**Present study**	**7.8**

CHART NO. 8 MEAN DIAMETER OF POPLITEAL ARTERY



The diameter of the normal PA is not uniform throughout the length. In most of the studies, mid popliteal diameter was taken into consideration to assess the risk of development of Popliteal aneurysm. When the PA diameter is more than 2 cm, it is considered as popliteal aneurysm.

4. BRANCHES OF POPLITEAL ARTERY

Henry Hollinshed[21] (1997) stated that the PA gives five genicular branches and muscular branches to muscles of popliteal fossa.

Gray's Anatomy: Susan Standring[69] (2012) indicated that PA has

- Five genicular branches
- Superior muscular branches : to adductor magnus and hamstrings
- Inferior muscular branches : sural arteries are two in number and suppies
- Gastrocnemius, soleus and plantaris (they are used in gastrocnemius musculocutaneous flap)
- Cutaneous: the superficial sural arteries. (fascio cutaneous free and pedicled flaps may be raised on the superficial sural arteries)

Zuhal Ozgur[42] (2009) in his cadaveric study, found that the ILGA arise from ATA. The IMGA arise from common tibioperoneal trunk .

Salaria and Atkinson [57]**(2008)** studied in eighteen specimens and stated that there is a common trunk for MGA, SLGA in 12.5% of the specimen.

Singla et al[63] **(2012)** observed in 60 specimens that there is a common trunk for MGA, SLGA in 1.6 % of the specimens.

Billakanti et al[7] **(2014)** stated that IMGA which is usually a branch of PA was found to be arising from ATA.

Bettaiah et al[5] (2016) observed in 40 specimens and reported that common trunk for MGA, SLGA was nil, while common trunk for MGA, SLGA and SMGA was observed to be 5% of the specimens.

In the **present study,** out of fifty specimens, forty nine specimens showed usual branching pattern. In one specimen ILGA arose from ATA instead of PA. (Perforators of PA and its branches are of two types musculocutaneous and septocutaneous perforators.

Lateral genicular artery flap is a fascio cutaneous flap used for knee reconstruction with low donor site morbidity. This flap showed constant anatomy and is reliable for coverage of defects at superior and lateral portion of the knee and proximal part of the lower leg. In ATA, 2 perforators may be present in the anterior compartment of the leg. PTA perforators may emerge between flexor digitorum hallucis and soleus.

A Sciatic block performed in the area just above the popliteal fossa is called Popliteal or low sciatic block.

PRA perforator flap is used in reconstruction of defects in the lateral aspect of the middle and distal third of leg and ankle. If there is hypoplasia of both ATA and PTA, harvesting of PRA is contraindicated since, PRA is the only artery that feeds the distal parts of the lower limb.

An arteriogram done before approaching the popliteal region for vascular surgeries may give adequate information about the branching pattern of PA. Knowing the possible variations in prior reduces time spent on exploring occluded arteries. PA pulse may be absent when there is occlusion of the FA. Distal foot pulse will be absent in tibioperoneal diseases.

5. TERMINAL DIVISION OF POPLITEAL ARTERY

Kim D et al[28] (1989) in his angiographic study of 605 extremities described 92.2% of normal pattern.

G.J.Romanes[55] (1996) stated that the PA ends at the inferior border of the popliteus and there it divides into anterior tibial and posterior tibial arteries.

Cornelius Rosse, Penelope Gaddum Rosse[10] (1997) stated that the PA ends by dividing into anterior tibial and posterior tibial arteries at the inferior border of popliteus.

Keith L. Moore [37](2006) described that the PA ends at the lower border of popliteus by terminating into anterior and posterior tibial arteries.

Sanders RJ, Alston GK[5] (1986) in their angiographic study in 147 patients (294 limbs) normal pattern was observed in 97%.

Tindall AJ[72] (2006) in his angiographic study of 100 knees, 94% normal pattern was observed.

SZpinda M [56](2006) in his angiographic study in 152 limbs, 87.75% of normal branching pattern was reported.

Day CP [12] (2006) in his study on 1037 limbs (angiographic study), 90.7% showed normal pattern.

Ozgur Z et al [42](2009) in his cadaveric study of 40 lower limbs, 90% showed normal pattern.

Kil SW[27] (2009) in his angiographic study on 1242 limbs, found 89.2% of normal pattern.

Mavili E et al[36] (2011) in his angiographic study of 535 limbs, reported 88.1% of normal pattern.

Kropman et al[29] (2011) in cadaveric study of 7671 limbs, reported 90% of normal pattern.

Susan Standring[69] (2012) stated that PA divides at distal border of popliteus in 90% of specimens.

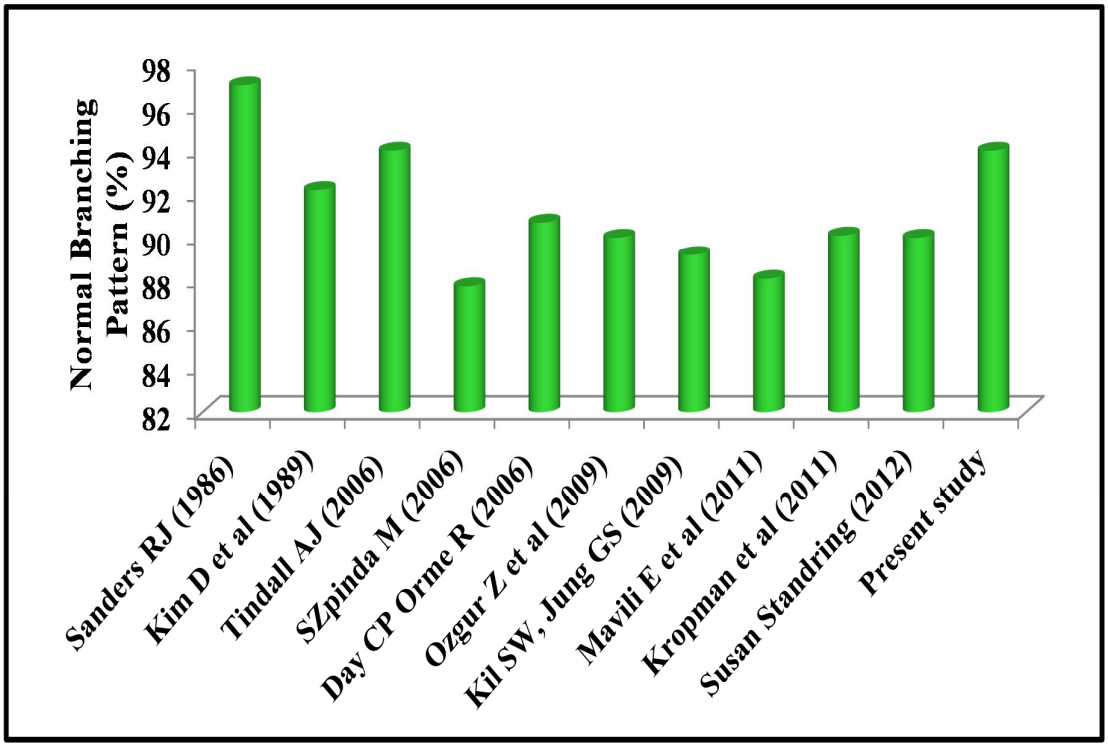
In the present study out of the fifty specimens, normal branching pattern was observed in 48 specimens (96%). This closer with the reports of **Tindall AJ[72] (2006), Kim D et al [28](1989) and Sanders RJ et al[58](1986).**

Diabetic patients more prone to occlusive lesions in the tibial arteries, so it is essential that arteriogram incorporate the complete infrapopliteal circulation including the foot vessels.

TABLE NO. 9: NORMAL BRANCHING PATTERN OF POPLITEAL ARTERY

S.NO	NAME OF STUDIES	NORMAL BRANCHING PATTERN (%)
1.	Sanders RJet al (1986)	97
2.	Kim D et al (1989)	92.2
3	Tindall AJ et al (2006)	94
4	SZpinda M et al (2006)	87.75
5	Day CP et al (2006)	90.7
6	Ozgur Z et al (2009)	90
7	Kil SW et al (2009)	89.2
8	Mavili et al (2011)	88.1
9	Kropman et al (2011)	90.1
10	Susan Standring (2012)	90
11	**Present study**	**96**

`CHART NO.9: NORMAL BRANCHING PATTERN OF POPLITEAL ARTERY



Normal level of division occurs in the lower border of POP. The normal branching pattern is PA dividing into ATA and PTA. PRA arises from PTA in (90%) of subjects. In 5% of PA shows high division proximal to lower border of popliteus, or it may trifurcate into ATA, PTA, PRA. Either the ATA or the PTA may be reduced or increased in calibre. The calibre of the PRA is usually inversely related to that of ATA and PTA, . Rarely, the ATA is the source of PRA, in which case PA shows high division.

Lippert and pabst[33] in his study identified a vessel directly connecting the PA at the level of the knee joint to the proximal part of the tibioperoneal trunk , which was named as“ISLAND”.

Variations in the branching pattern of PA will influence the surgical approach and choice of suitable arterial graft sites. Trifurcation is a challenge during angioplasty or embolectomy. In the absence of PTA and ATA, the PRA becomes only source of blood supply to the foot.

6. HIGH DIVISION OF POPLITEAL ARTERY

Adachi[1] (1928) defined HDPA as any terminal division of PA, which takes place at a level above the middle of the posterior surface of POP. He observed HDPA in 2.8% of total 770 specimens.

Parson and Robinson et al [44](1898) dissected 106 specimens and observed HDPA in 8.2%.

Trotter et al[73] (1940) reported 6.2% of HDPA out of 264 specimens.

Keen et al[25] (1961) reported 5% of HDPA in total 280 specimens.

Bardsley and Staple et al[3] (1970) reported 5.9% of HDPA in angiographic studies.

Kim et al [28](1989) studied 1000 femoral angiogram and reported 4.66% of HDPA.

Mauro et al [35](1988) observed 421 lower extremity angiogram and reported 2.3% of HDPA.

Colborn et al[9] (1994) dissected 42 specimens and reported 7% of HDPA.

Somayaji et al[67] (1996) dissected 250 limbs and observed HDPA in 25 specimens.

Tindall et al [72](2006) in Doppler study observed 6% of HDPA in 100 specimens.

Barut et al[4] (2009) observed 3.57% HDPA in 28 specimens.

Singla et al [63](2012) reported 3.3% of HDPA in 60 specimens.

Ankit Khandelwal et al[26] (2014) reported 5% of HDPA in 40 specimens.

Oztekin et al [43](2015) reported one case of HDPA out of 495 extremities (0.2%).

In the present study, out of fifty specimens, one specimens showed high division of PA (2%). This is closer to the reports of **Keen et al[25](1961), Kim et al[28] (1989) and Ankit Khandelwal et al[26] (2014).**

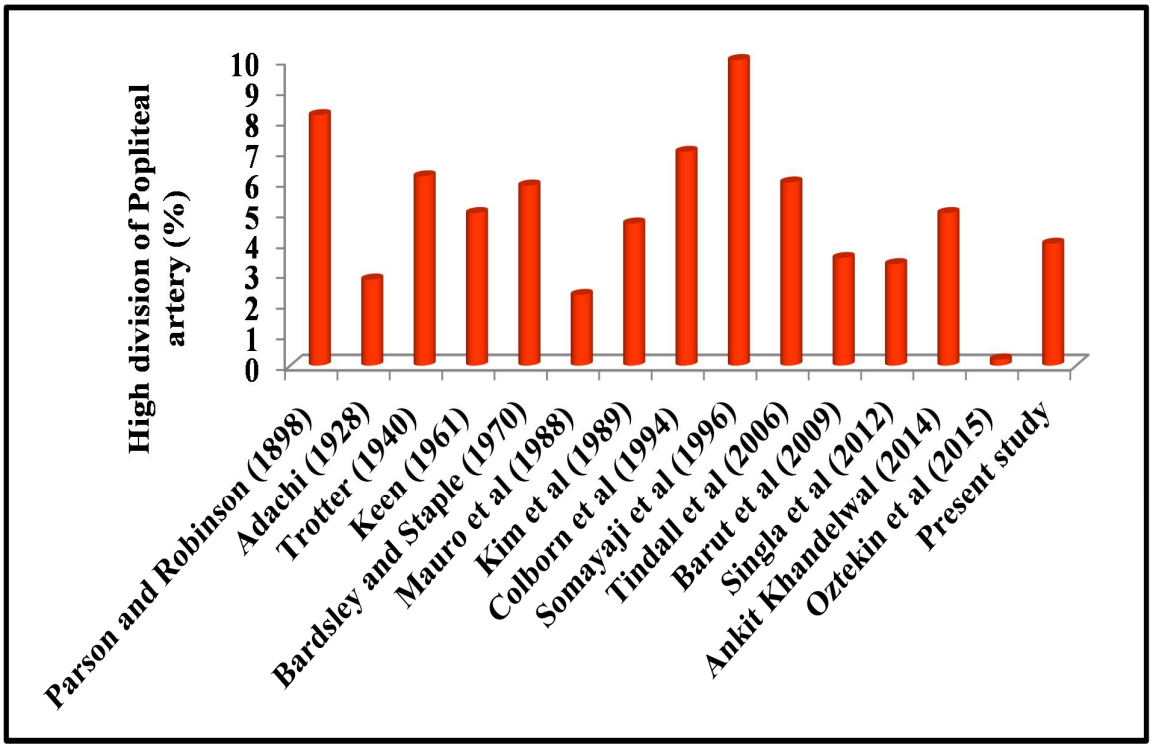
High origin ATA is surgically important as it is in direct contact with posterior surface of tibia . It has high risk of injury during knee arthroplasty, high tibial osteotomy and total knee replacement procedures. When a transverse tibial cut is made through the tibial cortex using osteotomy drill, ATA is more prone to injury.

The knowledge of variation of termination of PA is important during arthroscopic knee surgery to minimize the surgical complication.

TABLE NO.10: HIGH DIVISION OF POPLITEAL ARTERY

S. NO	Name of the Study	High division of Popliteal Artery (%)
1.	Adachi et al (1928)	2.8
2.	Trotter et al (1940)	6.2
3.	Keen et al (1961)	5
4.	Bardsley and Staple et al (1970)	5.9
5.	Mauro et al (1988)	2.3
6.	Kim et al (1989)	4.66
7.	Colborn et al (1994)	7
8.	Somayaji et al (1996)	10
9.	Tindall et al (2006)	6
10.	Barut et al (2009)	3.5
11.	Singla et al (2012)	3.3
12.	Ankit Khandelwal et al (2014)	5
13.	Oztekin et al (2015)	0.2
14.	**Present Study**	**2**

CHART NO: 10 HIGH DIVISION OF POPLITEAL ARTERY



6. TRIFURCATION OF POPLITEAL ARTERY

Quain[50] (1844) reported 2.3% trifurcation in 258 specimens.

Adachi[1] (1928) stated that when all three terminal branches arise together at the level of lower border of the POP, it can be considered as trifurcation. He observed 0.8% of trifurcation in 770 specimens.

Trotter et al[73] (1940) reported 0.5% trifurcation in 1168 specimens.

Keen et al[25] (1961) observed 4.3% trifurcation in 280 specimens.

Morris et al[38] (1961) observed 2.9% trifurcation in 246 femoral angiograms.

Bardsley et al[3] (1970) mentioned that in 235 specimens, 0.4% of trifurcation was observed.

Lippert et al [33](1985) reported 4% of trifurcation in his study.

Kim et al [28](1989) studied 605 specimens and observed 2% of trifurcation.

Mauro et al[35] (1989) studied 343 angiograms and noted 4.1% of trifurcation.

Neville et al[41] (1990) reported 1.9% trifurcation in 4108 lower limb specimens.

Ozgur et al[42] (2009) dissected 45 specimens and reported 2.5% trifurcation.

Sawant et al[70] (2013) studied 120 specimens and reported 5% trifurcation

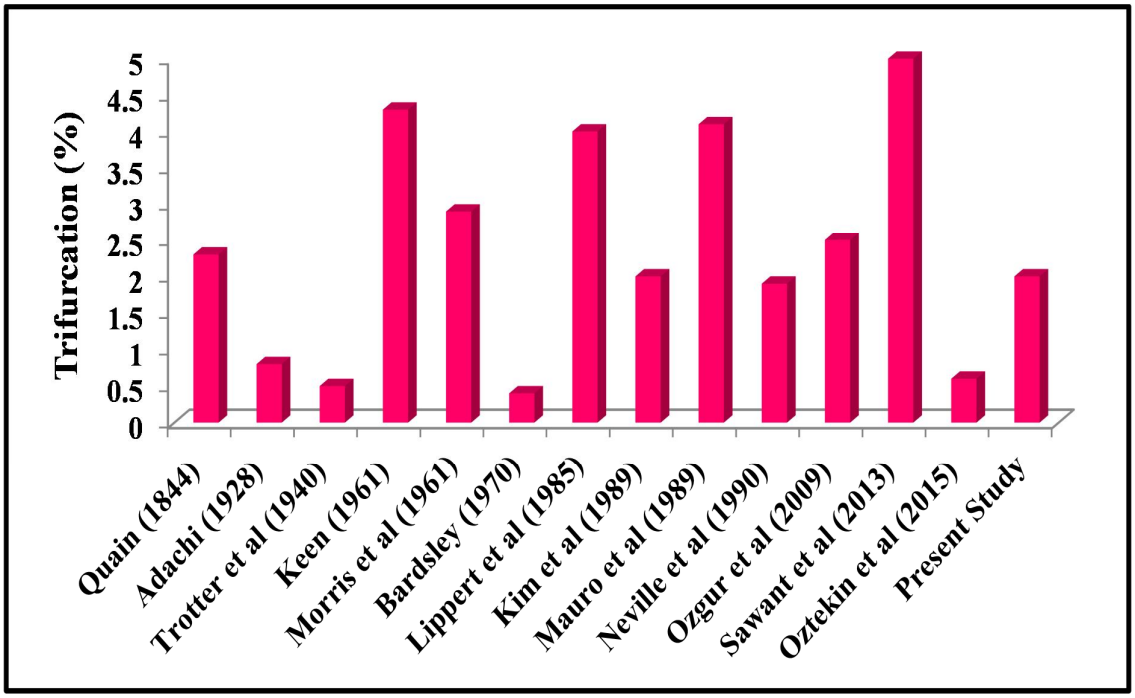
Oztekin et al[43] (2015) reported trifurcation in 3 specimens out of 495 extremities (0.6%).

In the present study out of fifty specimens observed, one specimen showed trifurcation (2%). Result of the present study closer with the reports of **Adachi[1] (1928), Morris et al[38] (1961), Kim et al[28] (1989) and Ozgur et al[42] (2009).**

TABLE NO. 11: TRIFURCATION OF POPLITEAL ARTERY

S. No	Name of the Study	Trifurcation (%)
1.	Quain (1844)	2.3
2.	Adachi et al (1928)	0.8
3.	Trotter et al (1940)	0.5
4.	Keen et al (1961)	4.3
5.	Morris et al (1961)	2.9
6.	Bardsley et al(1970)	0.4
7.	Lippert et al (1985)	4
8.	Kim et al (1989)	2
9.	Mauro et al (1989)	4.1
10.	Neville et al (1990)	1.9
11.	Ozgur et al (2009)	2.5
12.	Sawant et al (2013)	5
13.	Oztekin et al (2015)	0.6
14.	**Present Study**	**2**

CHART NO.11 - TRIFURCATION OF POPLITEAL ARTERY



RELATIONS OF POPLITEAL ARTERY TO THE ADJACENT NEUROVASCULAR STRUCTURES

G.J.Romanes[55] (1996) stated that from above downwards the superficial relations of PA are semimembranosus, PV, TN and gastrocnemius with plantaris.

Cornelius Rosse and Penelope Gaddum Rosse [10](1997)stated that deeper in the popliteal fossa is the PA. The PV is directly superficial to it and TN is back to the vein.

Arthur F Dalley[2] (2006) The PV lying superficial to the PA and in the same fibrous sheath.

In a study done by **Srijit Das & Neela Vasudeva[68] (2007),** 2% of specimens showed abnormal relation, where the PA passed superficial to PV.

A.Halim[19] (2008): TN and PV lies superficial to the PA. The TN crosses the popliteal vessels from lateral to medial side as it courses downwards.

D.K. Kadasne[24] (2009): The PV follow the artery but lies superficial to it and the TN lies superficial to artery and vein.

Anne M.R.Agur, Arthur F Dalley [2](2009): The TN is superficial to the PV, which in turn is superficial to the artery.

Richard S. Snell[66] (2010): TN crosses the PA from lateral to medial side. The PV lies superficial to the PA.

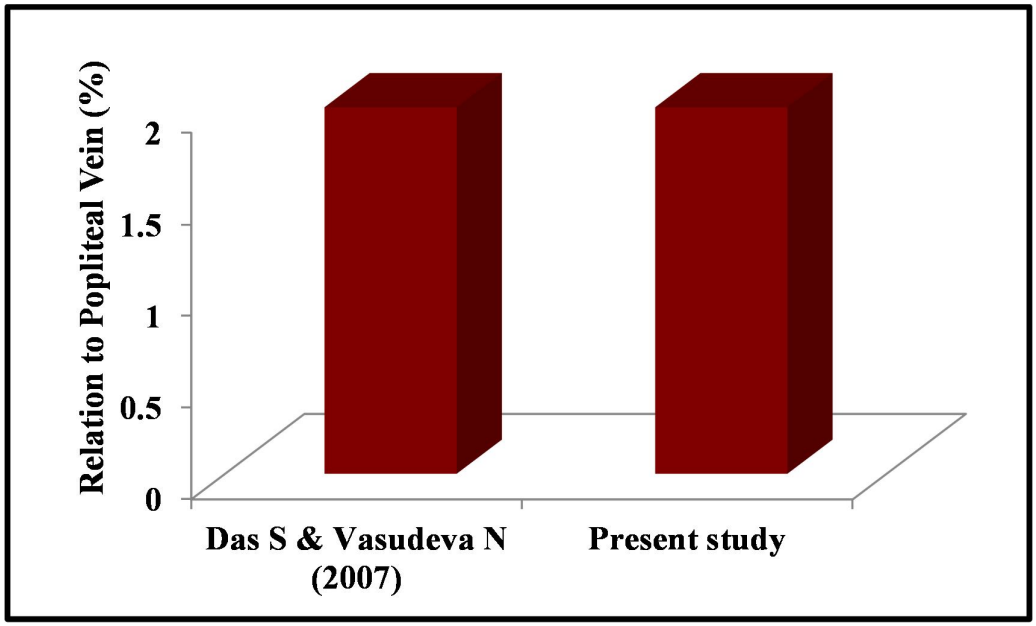
Chummy S. Sinnatamby[64] (2011): Throughout the popliteal fossa, the PA is deepest of large neurovascular structures in the popliteal fossa. At all levels PV lies between the artery and nerve.

Susan Standring- Gray'sAnatomy[69](2012)PA crossed from its lateral to medial side by TN and PV. The PV lies between TN and PA. The PV is usually superficial and adjacent to the PA. The vein may be separated from the artery by a slip of muscle derived from the medial head of gastrocnemius.

In the present study out of fifty specimens, forty nine showed PA lying deep to PV and TN (98%). One specimen showed PA lying superficial to PV (2%), which coincides with the report of **Srijit Das & Neela Vasudeva[68] (2007).**

The PV is usually superficial and adjacent to the artery, sometimes it may run deep to the artery. It may be separated from the PA by a slip of muscle derived from the medial head of gastrocnemius.

CHART NO.12: RELATIONS OF POPLITEAL ARTERY TO THE POPLITEAL VEIN



Conclusion

CONCLUSION

The Popliteal artery and its branching pattern have been of great interest to anatomists and surgeons, due to wide clinical and radiological significance. Present study was done to document and provide information of both normal and variant morphology of the PA in adult human cadaver by dissection method. The origin, course, length, diameter, branches, terminal branching pattern and its relations to the adjacent neurovascular structures of PA were observed in the present study. Several researches regarding this study have been carried out in the past. The following conclusions were drawn from the present study

1. The origin of the PA is the continuation of FA in all the specimens.
2. The mean length of PA was 18.6 cm.
3. The average diameter of PA was 7.8mm.
4. Unusual origin of Inferolateral genicular artery from ATA was documented in one specimen.
5. Variations of terminal branching pattern of PA observed were
    - High division of PA
    - Trifurcation of PA into anterior tibial, posterior tibial and peroneal arteries.
    - PA was related superficial to PV in one of the specimen.

Awareness of these variations will be beneficial to angiographers for the evaluation of arteriograms and to vascular surgeons for various surgical approaches. It will also help the plastic surgeons to select the suitable arterial graft sites. Sometimes, it may be necessary for the surgeons to modify the surgical techniques and approaches due to these anatomical variations.

High origin ATA passes beneath the popliteus and is in direct contact with posterior surface of tibia. It is thus vulnerable during knee arthroplasty or high tibial osteotomy[63].

Knowledge of variations of PA bifurcation point and branching pattern is mandatory for vascular surgeons to avoid complication during various surgical approaches in popliteal fossa region. It is important for the

I. Orthopedicians while doing surgeries in knee joint.
II. For the surgeon operating on aneurysm of PA
III. For the radiologist performing angiographic study.

Awarness of these variations may have clinical implication regarding vascular grafting, direct surgical repair, transluminal angioplasty, embolectomy or diagnosis of arterial injury[27].

The increasing number of surgical reconstructions and percutaneous vascular procedures involving lower limb added the importance of recognition of these variations. Before performing surgical or intervention procedures in lower extremity, patients should be comprehensively evaluated for disease or anatomical variation for the success of the procedures.

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MASTER CHART

Specimen No:	Origin of PA	Length of PA (cm)	Diameter of PA (mm)			Course of PA	Branches	Terminal branching pattern	Relation of PA to adjacent neurovascular structures
			At the level of AH	Mid point	Bifurcation level				
1	FA	16.7	5.9	6	4.4	N	NBP	NBP	PA deep to PV
2	FA	16.72	6	6.2	5.4	N	NBP	NBP	PA deep to PV
3	FA	16.74	5.8	6.35	5.2	N	NBP	NBP	PA deep to PV
4	FA	16.76	6.1	6.5	5.9	N	NBP	NBP	PA deep to PV
5	FA	16.9	6.5	7.78	6.3	N	NBP	NBP	PA deep to PV
6	FA	17	6.2	6.8	5.4	N	NBP	NBP	PA deep to PV
7	FA	17.23	6.3	6.9	5.8	N	NBP	NBP	PA deep to PV
8	FA	17.5	6.2	7	5.9	N	NBP	NBP	PA deep to PV
9	FA	18	6.5	7.5	6.2	N	NBP	NBP	PA deep to PV
10	FA	15.2	6.5	7.12	5.9	N	NBP	HDPA	PA deep to PV
11	FA	18.5	6.4	7.23	5.6	N	NBP	NBP	PA deep to PV
12	FA	18.63	6.4	7.4	5.8	N	NBP	NBP	PA deep to PV
13	FA	16.92	6.3	7.55	5.8	N	NBP	NBP	PA deep to PV
14	FA	17.87	6.7	7.56	6.4	N	NBP	NBP	PA deep to PV
15	FA	18.95	6.5	7.67	5.8	N	NBP	NBP	PA runs superficial to PV
16	FA	19	6.6	7.89	5.7	N	NBP	NBP	PA deep to PV
17	FA	19.25	6.9	8.7	6.4	N	origin of ILGA from ATA	NBP	PA deep to PV
18	FA	18.72	6.8	8.5	6.4	N	NBP	NBP	PA deep to PV
19	FA	19.5	6.5	7.95	6.5	N	NBP	NBP	PA deep to PV
20	FA	20.1	6.8	7.73	6.4	N	NBP	Trifurcation	PA deep to PV
21	FA	20.5	6.5	7.43	6	N	NBP	NBP	PA deep to PV
22	FA	19.16	6.2	6.72	5.9	N	NBP	NBP	PA deep to PV
23	FA	19	6.5	7.92	5.4	N	NBP	NBP	PA deep to PV
24	FA	20.5	6.3	6.95	5.2	N	NBP	NBP	PA deep to PV
25	FA	20.3	6.4	8.8	6.9	N	NBP	NBP	PA deep to PV
26	FA	18.12	6.9	8.3	6.4	N	NBP	NBP	PA deep to PV
27	FA	18.3	7.2	8.35	6.5	N	NBP	NBP	PA deep to PV
28	FA	18.6	7.2	8.42	6.4	N	NBP	NBP	PA deep to PV
29	FA	19.5	7.5	7.92	6.9	N	NBP	NBP	PA deep to PV
30	FA	19.3	7.2	7.94	6.5	N	NBP	NBP	PA deep to PV
31	FA	20.2	7.5	8.15	6.8	N	NBP	NBP	PA deep to PV
32	FA	20.3	7.3	8.8	6.7	N	NBP	NBP	PA deep to PV
33	FA	20.5	7.4	8.6	6.9	N	NBP	NBP	PA deep to PV
34	FA	18.23	7.2	8.73	6.8	N	NBP	NBP	PA deep to PV
35	FA	16.8	7.5	8.35	7.4	N	NBP	NBP	PA deep to PV
36	FA	16.2	7.9	8.76	6.8	N	NBP	NBP	PA deep to PV
37	FA	17.5	7	7.7	6.5	N	NBP	NBP	PA deep to PV
38	FA	17.23	6.5	7.6	6.4	N	NBP	NBP	PA deep to PV
39	FA	18	6.9	8.3	6.5	N	NBP	NBP	PA deep to PV
40	FA	18.05	7.2	8.5	6.9	N	NBP	NBP	PA deep to PV
41	FA	18.2	7.5	8.4	6.8	N	NBP	NBP	PA deep to PV
42	FA	18.6	7.4	8.5	6.9	N	NBP	NBP	PA deep to PV
43	FA	19.25	7.3	8.8	6.8	N	NBP	NBP	PA deep to PV
44	FA	19.7	6.8	7.8	6.5	N	NBP	NBP	PA deep to PV
45	FA	19.2	5.8	7	6.3	N	NBP	NBP	PA deep to PV
46	FA	20.3	7.4	8.5	6.8	N	NBP	NBP	PA deep to PV
47	FA	20.5	6.4	7.35	6.5	N	NBP	NBP	PA deep to PV
48	FA	20.16	7.5	8	6.8	N	NBP	NBP	PA deep to PV
49	FA	20.27	7.4	8.8	6.9	N	NBP	NBP	PA deep to PV
50	FA	20.5	7.5	8.58	6.5	N	NBP	NBP	PA deep to PV

FA- Femoral artery; N-Normal course; NBP – Normal branching Pattern; PA- Popliteal artery; PV- Popliteal vein; ATA- Anterior tibial artery; HDPA- High division popliteal artery